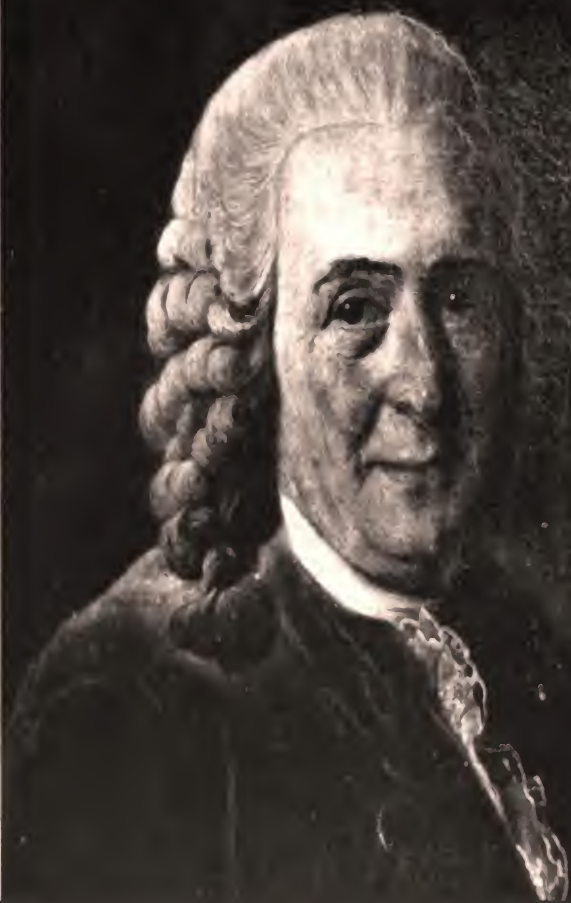




*Guide to an exhibition
of old natural history books*

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SPECIAL GUIDES: No. 1.

GUIDE TO AN EXHIBITION
OF OLD NATURAL HISTORY
BOOKS, ILLUSTRATING THE
ORIGIN AND PROGRESS OF THE
STUDY OF NATURAL HISTORY UP
TO THE TIME OF LINNÆUS.

British Museum.



LONDON:
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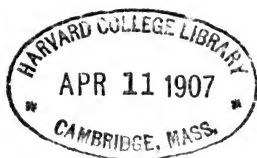
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P R E F A C E.

THIS Guide, which is intended to be the first of a special series, has been drawn up to accompany an exhibit of Old Natural History Books which illustrate the origin and progress of the study of Natural History up to the time of Linnæus.

It makes no pretence of giving a complete history of the contributions of all writers, but is practically limited to such works as have contributed to the advancement of the science.

It has been compiled chiefly by the Assistant in charge of the General Library, Mr. B. B. Woodward, with assistance in technical matters from officers in the several departments, and from members of the staff at the British Museum, Bloomsbury.

E. RAY LANKESTER,
Director.

BRITISH MUSEUM
(NATURAL HISTORY),
March, 1905.

ON THE ORIGIN AND PROGRESS OF THE STUDY OF NATURAL HISTORY UP TO THE TIME OF LINNÆUS, AS ILLUSTRATED BY A SERIES OF OLD WORKS ON NATURAL HISTORY IN THE MUSEUM.

OF THE earliest beginnings of the proper study of Natural History no information is available, or to be expected ; it began with the dawn of civilisation, and doubtless had its origin, so far as animals and plants were concerned, in the primitive observations of the Hunter and of the Medicine-man, or Priest-Physician, while the search for stone, and subsequently for metals, with which to fashion weapons and tools, served to draw attention to the nature and structure of the earth.

That the Hunters of the Stone Age were not unobservant of the Quadrupeds they pursued is evinced by the carvings and the incised outline representations on bone, as well as the really remarkable pictures, drawn in manganese and red ochre, on the chalk walls of some caves in the South of France (Dordogne).

Nos. 1
& 2.

No. 3.

Plants they do not appear to have delineated, although many of the animals are depicted in the act of browsing.

Both Plants and Animals, on the other hand, appear on Egyptian and Assyrian monuments, though they figure as adjuncts to the scenes depicted, and not as the central objects of the design.

At the same time the love of the Egyptians for Animals of all sorts, especially for those sacred to special deities, is well known. These, such as the Cat, Dog, Hawk, Ibis, &c., and

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in some districts the Monkey and Crocodile, were carefully embalmed at death.

The ancient Egyptians, however, made no systematic study of Natural History ; nor did the early Greek philosophers.

Some scattered observations are met with among the writings of the latter, while to PYTHAGORAS [B.C. 569-470] have been attributed ideas concerning the changes in relative level between sea and land that may not improbably be those of later observers. HERODOTUS [B.C. 484-406] certainly mentions the occurrence of shells, presumably marine, on the hills of the Nile Valley, and deduces from that and other facts the former extension of the sea over that area.

HIPPOCRATES [B.C. 460-361], the priest-physician, and "Father of Medicine," mentions the uses of some 240 plants.

THE first person, however, to whom belongs the credit of instituting a genuine study of Natural History was ARISTOTLE [B.C. 384-322], and he has therefore been justly called the "Father of Natural History."

His writings on Animals, of which he appears to have known some 500 species, would seem to contain a certain admixture of astronomical symbolism ; or else portions belonging to his astronomical writings were by an error of his first transcribers incorporated with those on animals, and this, considering the conditions under which his MSS. had been preserved, would not be remarkable.

Although Aristotle proposed no definite classification of Animals, it is deducible from his writings that he divided them into Enæma, or those having (red) blood, and Anæma, or those without, and subdivided the former, or Vertebrata, into :—Vivipara, Birds, the other Ovipara, and Fish ; while the latter, or Invertebrata, were subdivided into :—Malakia, Malakostraka, Entoma, and Ostrakoderma. The insects (Entoma) he yet further subdivided, and three of his groups, Coleoptera, Psychæ [= Lepidoptera] and Diptera, hold good at the present day. The only formal terms of classification employed by him are eidos, or species, and genos, or genus, the latter being far more vaguely used than at the present day.

In Botany and Mineralogy little was done by Aristotle, and

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nothing in Geology as now understood, although it is interesting to note in passing that he maintained the earth to be a spherical body, while he was acquainted with the occurrence of fossils in the rocks, and discussed the changes on the earth's surface necessary to account for them.

It was Aristotle's favourite pupil THEOPHRASTUS [B.C. 371-286], to whom he bequeathed his MSS., who took up the subjects of Botany and Mineralogy. Theophrastus described some 500 kinds of Plants used in Medicine, which he roughly grouped according to size and texture, or use. He theorized on the existence of sexes in plants, but made no observations himself. Minerals were at that time classified into "Metals" and "Stones," and only his treatise on Stones has survived: it is chiefly interesting as showing what characters were made use of at that time for the discrimination of Minerals and the description of the species, as well as a record of the places of their occurrence.

After many vicissitudes, which included burial in a catacomb, the remains of the combined MSS. of Aristotle and Theophrastus passed into the hands of Apellicon of Teos [-B.C. 85], who attempted their restoration and had them copied. The transcripts were afterwards seized by Sylla and conveyed to Rome, where they were subsequently edited and given to the world by Andronicus of Rhodes; but their real publication dates from 1495, when they were first printed in the original Greek by the celebrated Venetian printer, Aldus Manutius. No. 4. A Latin translation by T. Gaza of Theophrastus' *De historia et causis Plantarum*, had, however, been printed at Treviso in 1483.

GEOLOGY, or more strictly speaking, physical geography, first received serious attention at the hands of STRABO [B.C. 63? - A.D. 24], who originated the theory of the alterations of the level of the land in relation to the sea, in contradistinction to the former belief in the changes of the sea-level. His *Geographicon*, which was written in the early years of the Christian Era, was printed, from the Latin translation, at Venice in 1472 by Vindelinius de Spira, and appeared in the original Greek in 1516 from the press of Aldus Manutius.

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No. 5.

THE oldest popular natural history book, and almost encyclopædia, was the *Historia Naturalis*, also termed the *Historia Mundi*, of PLINY THE ELDER [A.D. 23-79]. This voluminous treatise in thirty-seven books has been preserved, and presents an epitome of the state of Roman knowledge on the subject. The number of known Plants had by this time increased to about one thousand, and the belief in the existence of sexes in Plants had become established; while in the Minerals the "Earths" had been made into a class apart from "Metals" and "Stones." It was probably the earliest work on Natural History to be printed, the editio princeps emanating from J. de Spira's press at Venice in 1469.

THE next most important work was the celebrated *Materia Medica* of DIOSCORIDES [A.D. 40? -]. This was a standard book for over a century and was the basis for most of the early Herbals.

It was first printed at Medemblik, Holland, in 1478, from a Latin translation, made by Hermolaus Barbarus. The Greek editio princeps, from the press of Aldus Manutius, at Venice, appeared in 1499. The work became the subject of much discussion, and of many Commentaries by early Botanists of the Renaissance, especially P. A. MATTIOLI [1500-1577] and his contemporaries, who, ignorant of the differences between the floras of east and west Europe, were led into endless difficulties in their attempts to identify their plants from the imperfect definitions of Dioscorides.

THE three Greek writers, Hippocrates, Theophrastus, and Dioscorides, are the authorities for all the Greek names of Plants up to the Christian Era.

WITH the epoch of Pliny and Dioscorides the classical period of Natural History may be said to have been brought to a close: the works of the older writers became less studied in Europe, and commonplace-books like those of Ælian of Praeneste, a compiler who lived in the third century, were much used. In these, scraps of folk-lore, travellers' tales and fragments of misapprehended science were set forth in the elegant style then affected. An edition of Ælian's collected

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works was issued by Gesner in 1556, and a good edition of his *De Natura Animalium* was brought out in 1774 under the editorship of Abraham Gronovius. No. .

The early Christian writers, none too conversant with Natural History, utilized these works, without question as to their reliability, in their allegorical interpretations of Biblical texts. Hence arose a series of collections, in many languages, of some fifty Christian allegories, much read and quoted in the Middle Ages, known by the common title of the *Physiologus*, or, since most of its imagery was borrowed from the animal world, the *Bestiary*.

On such productions as these were based the Natural History writings of the Middle Ages—"Dark" indeed as regards progress in scientific learning.

WHILE the works of the classical writers were neglected in Europe, their study was taken up by the Arabian Philosophers, who made some advance, more especially in the knowledge of medicine and chemistry, and their contributions were largely utilized in works issued in the centuries immediately succeeding.

Among these Arabian philosophers three call for special mention.

HUSAIN IBN 'ABD ALLĀH, called IBN SĪNĀ, or AVICENNA [980-1037], whose *Canon* (first printed about 1470) was the principal authority in medical matters for centuries, wrote on the formation and classification of Minerals. He merged the "Stones" and "Earths" into a single class, but, on the other hand, created two additional classes, "Salts" and "Sulphurs," the latter including various combustible substances (*e.g.*, bitumen) which, at that time, were held to contain sulphur.

SERAPION, or YŪHANNĀ IBN SARAPION [fl. 8th or 9th century] was author of the oldest known treatise on medicine in Arabic. A Latin translation by Symon a Cordo, *Liber Serapionis aggregatus in medicinis Simplicibus*, printed at Parma, in 1473, by Antoninus Zarotus, is one of the oldest known Herbals. No. 14.

AVERROES, or MUHAMMAD IBN AHMAD [1149-1198], chiefly celebrated for his Commentaries on Aristotle, also wrote

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a medical work (largely drawn upon by later compilers of Herbals), of which a Latin translation first appeared in 1490.

AMONG mediæval European writers the following deserve notice :—ALBERTUS (Albert von Bollstädt), called ALBERTUS MAGNUS [1193–1280], a Dominican, and sometime Bishop of Ratisbon, who, among his numerous writings, included Commentaries on Aristotle and treatises :—*De Animalibus*, first printed in 1479, *De Mineralibus*, printed 1495, and *Tabula tractatum parvorum naturalium* (in which were comprised his *De Vegetabilibus et Plantis*) printed in 1517.

No. 9.

No. 8.

VINCENTIUS BELOVACENSIS, or VINCENT OF BEAUVAIS [c. 1190–c. 1264], another learned Dominican, who resided at the court of Louis IX. of France, compiled at the instance of that king a *Bibliotheca Mundi*, which is not only one of the earliest of encyclopædias, but the greatest of the Middle Ages. The first part, entitled *Speculum Naturale*, written about 1250, contains thirty-three books. It was first printed at Strasburg about 1473.

No. 7.

BARTHOLOMÆUS (Bartholomew de Glanville), called BARTHOLOMÆUS ANGLICUS [fl. 1230–1250], a Minorite Friar, compiled an encyclopædia entitled : *De Proprietatibus Rerum*, which as a manuscript was known in Italy in 1283 and in England in 1296. It was first printed at Basle about 1470, and was the source of common information on Natural History during the Middle Ages.

No. 13.

THESE authors were followed after a long interval by :—

LEONARDO DA VINCI [1452–1519], who was not only a great painter, but had also vast knowledge, among other subjects, of Anatomy, Botany, and Geology. He vigorously maintained that the contents of the rocks were real shells, and supported the belief in the changes of sea and land which this view implied. His writings on these subjects were not printed from the original manuscripts till 1881 and 1883.

GIROLAMO FRACASTORO [1483–1553] declared his opinion that fossil shells had all belonged to animals which had lived and multiplied in the places where their exuviae are now found, but he was not listened to.

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AMONG other manuscript books in circulation at the time of the invention of printing were some household recipe-books for medicines, or Herbals, compiled by unknown persons from the works of various old medical writers and other sources.

Among the earliest of these Herbals were the *Herbarius* of Apuleius, printed at Rome about 1480, or later; and the *Herbarius*, also known as the *Aggregator practicus de Simplicibus*, which was issued in 1484 by the Mainz press. Both contain crude woodcuts of the plants, and the latter went through several editions.

No. 10.

No. 15.

Another Herbal of note was the *Ortus Sanitatis* by J. von Cube, issued about 1475 at Mainz, in German. Latin editions appeared about 1490 and later, but are undated and mostly without any indication of the place of imprint.

Nos. 11
& 12.

Many of these Herbals contained accounts of the Animals as well as of the Plants used in medicine, and were illustrated by quaint wood-cuts; some of the subjects depicted are recognizable, while some refer to purely legendary creatures, and other figures are creations of the artist, who had only the names and vague descriptions to guide him, and who consequently produced some truly remarkable illustrations.

The earliest English Herbal appears to have been *The Grete Herbal*, translated from the French, and printed at "London in Southwark" by Peter Treveris in 1526; while among the latest were *The Garden of Health*, by Wm. Langham, London, 1633; *The English Physician*, by N. Culpeper, London, 1652; and the *Botanologia* of Wm. Salmon, 2 vols., London, 1710-11. Culpeper's was a most popular book, and was re-issued in various forms down to quite recent times.

No. 16.

No. 19.

WITH the close of the fifteenth century the Credulous or Legendary period of Natural History study gave place to an era of renewed investigation at first hand; and this renaissance was furthered by the discovery of new Animals and Plants in distant countries as one of the first results of the period of great geographical discovery then initiated.

FROM the confusion engendered by the Herbals, with their more or less mythical Plants and Animals, the study of Botany was the first to be rescued and restored to its proper place as a

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- science by OTTO BRUNFELS [1488–1534], whose well illustrated
 No. 17. *Herbarium* was printed at Strasburg in 1530–1536.

Among his botanical contemporaries and successors were :—

EURICIUS CORDUS [*i.e.*, Heinrich Eberwein, 1486–1535], who wrote a *Botanologicon*, published at Cologne in 1534 ; and his son VALERIUS [1515–1544], who annotated Dioscorides, and also wrote on Metals.

JOHANNES RUELLIUS [c. 1474–1537] whose *De natura Stirpium* appeared at Paris in 1536.

HIERONYMUS BOCK [1498–1554], better known under the Latin version of his name as TRAGUS, who was author of a celebrated *Kreütter Buch* first issued in 1539.

- No. 21. LEONHARD FUCHS [1501–1566], whose *Historia Stirpium* was printed at Basle in 1542, and is specially worthy of note on account of the excellence of its illustrations.

- No. 18. In England there lived at this time “The Father of English Botany,” WILLIAM TURNER [c. 1515–1568], Dean of Wells, whose *Libellus de Re Herbaria novus*, printed at London in 1538, is now a very scarce work. His *Names of Herbes* followed in 1548, and was very largely an extension in English of the *Libellus*. To this in 1551 succeeded the first part of his *New Herbal*, a beautifully printed work with good illustrations.

- No. 20. MINERALOGY and Metallurgy were next brought into more scientific order by GEORGIUS AGRICOLA, whose real name was BAUER [1494–1555], the “Father of Metallurgy.” Agricola was the first to make proper use of the external characters in the distinction and description of Minerals. He introduced the term *Succi Concreti* for those minerals which he regarded as the results of coagulation, and which he was unable to class with Earths, Stones or Metals. His *De ortu & causis subterraneorum* and *De natura Fossilium* appeared together in 1546 ; these were followed in 1556 by his *De Re Metallica*.

- No. 25. THE restoration of Zoology to scientific rank was the work of EDWARD WOTTON [1492–1555], who was the first English physician to make a systematic study of Natural History. In his *De differentiis Animalium*, printed at Paris in 1552, he discarded the legendary animals and reverted to the sounder methods of Aristotle.

- No. 26.

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His work was quoted with approval by CONRAD GESNER [1516–1565], the celebrated Swiss physician and naturalist, who wrote a series of natural history works that appeared at Zurich between 1551 and 1556. Gesner's Zoology was mainly a compilation ; but in Botany he introduced the first clear conception of genera, and proposed, in letters published after his death, the earliest methodical system of classification based on the structure of the flower and the seed. No. 27.

Gesner appears to have led the way in forming a proper Zoological Cabinet, and in laying out a Botanic garden.

WITH the advance of geographical exploration, works on the Natural History of regions beyond Europe and the Near East began to appear early in the sixteenth century.

Of these Northern Africa was naturally the first to receive attention, and LEO AFRICANUS, whose real name was HĀSAN IBN MUHAMMAD, but who afterwards assumed the name of GIOVANNI LEONE [– c.1526], wrote in Arabic a work subsequently published in Latin at Antwerp in 1556, as *De totius Africæ descriptione libri 9.*

The West Indies and North America were the next to receive attention. GONZALO FERNANDEZ DE OVIEDO Y VALDES [c.1478 – c.1560] wrote an *Historia general y natural de las Indias Occidentales*, of which the first twenty books were printed in 1535, though the whole fifty were not completed till 1783 ; while NICOLAS MONARDES [1493–1588], a Spanish doctor of Seville, described in 1569 the Plants and Animals used for medicine in the West Indies. No. 23.

The Near East as a whole was next treated of by PIERRE BELON [1517–1564], a French naturalist, in his *Observations de plusieurs singularitez* published at Paris in 1553. No. 22.

India and the Far East, a few years later, were the subject of treatises, principally on the drugs, by GARCÍAS DE ORTA, who, in 1563, published a *Coloquias dos Simples, e Drogas he cousas medicinais da India*, etc., of which a Latin version was issued at Antwerp four years later ; and by CHRISTÓBAL ACOSTA [–1580], whose *Tractado de las Drogas . . . de las Indias Orientales, con suas Plantas*, etc., appeared in 1578.

Brazil meantime was visited, when the French Protestants

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were there, by ANDRÉ THEVET [1502-1590], who in 1558 described *Les Singularitez de la France antarctique, autrement nommée Amérique*.

THE study of Fishes was at this time greatly advanced by three writers who are held to be the founders of modern Ichthyology :—PIERRE BÉLON [1517-1564], *De Aquatilibus*, Parisiis, 1553; GUILLAUME RONDELET [1507-1566], *Libri de Piscibus Marinis*, Lugduni, 1554-55; and IPPOLITO SALVIANI [1514-1572], *Aquatilium Animalium Historiæ liber primus*, Roma, 1554 [*i.e.*, 1557]. All three themselves saw and examined the Fishes they described, and gave faithful representations of them, but were more exercised to make out the names which the different kinds bore in the ancient writings than to describe them lucidly themselves.

FOR some time subsequently the history of the progress of Natural History was mainly that of Botany, and among the more distinguished writers were :—

REMBERT DODOENS [1517-1585], the well-known botanist and professor of physic at Leyden, who was author among many other works of a *Cruijde Boeck*, which was issued at Antwerp in 1554, but subsequently, being much sought after, went through many editions in several languages, including English. It was also issued in an abbreviated form by W. Ram, and as *Ram's Little Dodeon* (London, 1606) enjoyed considerable notoriety.

CHARLES DE LÉCLUSE [1526-1609], who travelled extensively in Western Europe making collections, wrote several books on the botany of the districts he visited, besides editing editions of the works of Dodoens, Orta and Monardes. He introduced exactitude, neatness and method into botanical descriptions, as well as the custom of giving references to the pages of works cited. In his *Rariorum Plantarum historia*, Antwerp, 1601, are given the earliest figures, from drawings made by him in 1589, of the Potato, which plant was growing in Italy in 1586.

MATTHIAS DE L'OBEL [1538-1616], at one time botanist to James I., had a physic garden at Hackney. He made many excursions and added a good many plants to the British Flora.

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In association with PIERRE PENA [fl. 1535-1605], he published, in London in 1570-71, a *Stirpium adversaria nova*, in which a rough classification of Plants into classes or groups is attempted. In 1576 his *Plantarum, seu Stirpium Historia* appeared at Antwerp; this was very fully illustrated, the printer, Plantin, having possessed himself of the blocks to works by Mattioli and Dodoens as well as to those edited by Lécluse. These figures were also issued apart from the text with an index in seven languages, and in this form made a popular work of reference for years, that was quoted by Linnæus. No. 30.

JACQUES D'ALECHAMPS [1513-1588], a French physician and botanist, whose *Historia Plantarum*, published at Leyden in 1586-87, gave account of over 1,000 species.

JACOB THEODOR, of Berg-Zabern, in Alsace, wrote, after the manner of his time, under his Latin designation as JACOBUS THEODORUS TABERNÆMONTANUS [1520-1590], and became quoted under the last name.* He wrote a *Neuw Kreuterbuch*, published at Frankfort in 1588-91, and noted for its illustrations. These figures were also issued as a separate work, entitled *Eicones Plantarum*, in 1590, and subsequently, 1597, used for Gerard's *Herbal*. No. 29.

A man of a very different stamp to the preceding was ANDREAS CÆSALPINUS [1519-1603], the celebrated Italian naturalist, who, besides being an eminent student of Aristotle (whose philosophy he explained and defended), was an original worker of note, with attainments that were considerably in advance of his times. He almost anticipated Harvey in the discovery of the circulation of the blood. In his *De Plantis*, published in Florence in 1583, he put in practice the method proposed by Gesner of classification by the fructification, and the care and thoroughness of this work elicited high praise from Linnæus, who styled him "primus verus systematicus."

He also contributed to the study of mineralogy, instituting a class for the minerals which are soluble in oil, corresponding to the class Salts, which included all soluble in water. In the same work (*De Metallicis*, Rome, 1596), he also maintained that fossil shells had been left on the land by the retiring

* There is, however, absolutely no justification for a modern citation of him as "Tabernaemontan."

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sea, and had concreted into stone during the consolidation of the soil.

- No. 33. Another Italian naturalist of note, FABIO COLONNA [1567–1650], published in 1592 a *Phytobasanos* remarkable for the beauty of its illustrations. He extended Cæsalpinus' method of classification to the formation of genera, but did not draw up a system. In Geology he was the first to point out in his *Osservazioni sugli Animali aquatili e terrestri* that some fossils belonged to marine and others to terrestrial testacea.

- No. 31. JOHN GERARD [1545–1612], a celebrated English botanist, had a garden in Holborn, of which he published a Catalogue (the first to be made of any garden) in 1596 and again in 1599. L'Obel's copy of the second edition is in this Museum, and contains his manuscript notes and denial of the attestation printed at the end stating that he had seen the plants growing in Gerard's garden that are enumerated in the work. Gerard's great work, however, was the *Herbal*, published in 1597, compiled chiefly from Dodoens after the method of L'Obel and illustrated by cuts mostly taken from a work of Theodorus Tabernæmontanus. He did much to advance the knowledge of Plants, while to him is due the discovery of many species then new to England.

- No. 34. THE next serious attempt, after that of Gesner, to compile a universal natural history, or encyclopædia, was made by ULISSE ALDROVANDI [1522–1607], the Italian naturalist, who spent his patrimony over the compilation and production of his series of well-known volumes, which were issued at Bologna between 1599 and 1668. He has fortunately preserved to us the accounts of Monsters, both mythical and actual, accepted up to his time.

- No. 32. THE study of Mineralogy was not greatly advanced at this period, and the only work of any note is that by ANSELM BOETHIUS DE BOODT [1550–1634], physician to the emperor Rudolf II., who published in 1609 a *Gemmarum et Lapidum historia*, which was long a work of practical value, although it was chiefly devoted to the minerals used as gems. In it he figures a lapidary's wheel which is practically identical with a kind in use at the present day.

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WITH the exception of the two last-named writers, the botanists continued the leaders of natural history study until far into the middle of the seventeenth century, the principal workers of note being :—

JEAN BAUHIN [1541–1613], a French physician and botanist, who wrote an *Historia Plantarum universalis*, which was issued after his death, under the care of Cherler and Chabræus, in 1650–1651. Though the classification was antiquated, the accuracy and clearness of the text caused Ray and others to attach great importance to this work.

CASPAR BAUHIN [1560–1624], brother to Jean, besides editing the works of Mattioli and Theodorus Tabernæmontanus, contemplated an exhaustive treatise on all known Plants.

The first and only published part of Vol. i. of his *Theatrum Botanicum* appeared posthumously in 1658 ; but his preliminary work, the *Pinax Theatri Botanici*, issued in 1623, that enumerated about 6,000 plants, became the universal text-book on Botany for nearly a century : it is quoted by Linnaeus in the latter's *Species Plantarum*. The distinction between genus and species is fully carried out in this work, and the nomenclature is very largely binomial.

THOMAS JOHNSON [–1644], an English botanist and physician, and afterwards colonel in the Royalist Army, was the author of the first local catalogues of Plants published in England. One of these referred to a part of Kent, and another to Hampstead Heath : they were issued in 1629 and 1632 respectively. He likewise brought out an improved edition of Gerard's "Herbal."

JOHN PARKINSON [1567–1650], Apothecary to James I. and Botanist to Charles I., is renowned for his book with the punning title *Paradisi in Sole Paradisus terrestris*, published in 1629 and quite lately reprinted. It is valuable as affording an exact view of the extent of floriculture at that period. His principal work, the *Theatrum Botanicum*, appeared in 1640, and contained descriptions of some 3,800 plants.

WILLIAM HOW [1620–1656] wrote the first British Flora. It appeared anonymously in 1650, under the title of *Phytologia Britannica*, and contains the names of 1,220 plants. No. 35.

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WITH the foundation, during the middle of the seventeenth century, of effective scientific societies, the study of Natural History may be said to have entered upon a fourth period of its development—the period of co-operation.

The regular assembling of both collectors and practical observers with the object of communicating the results of observations made, and discussing subjects of common interest, had great influence in encouraging and promoting all scientific pursuits.

As early as 1560 an *Accademia Secretorum Naturæ*, also known as *De Secretis*, had been founded at Naples, but coming into collision with the Church, was dissolved by the Pope.

In 1603 the *Accademia de' Lincei* was founded at Rome by Cesi, but flickered out at his death in 1630.

No publications of these bodies survive.

No. 38. In 1652 a number of German naturalists founded the *Accademia Cæsarea Leopoldino-Carolina Naturæ Curiosorum*: this society, however did not publish till 1670, whereas the *Royal Society of London*, which was founded in 1662 (having existed as an informal body from 1645) began to issue its

No. 37. *Philosophical Transactions* in 1665.

The French *Académie des Sciences* was founded in 1666 (its members having begun as a private society in 1630), but only began to print in 1702.

No. 39. In Italy the *Accademia del Cimento*, founded at Florence in 1657, issued its earliest *Saggi di Naturali Esperienze* in 1667; whilst the *Lincei*, revived for the third time in 1795 as the *Accademia Pontificia de' Nuovi Lincei*, did not venture on publication till 1851.

ALTHOUGH the study of Anatomy, as such, does not enter into the present history, certain important resultant Biological Discoveries of this period must be referred to, viz. :—

Firstly the discovery by WILLIAM HARVEY [1578–1657], of the Circulation of the Blood,* and his detection of the principle

* The circulation of the blood between the heart and lungs, and through the lungs, was known in 1553, and alluded to by the Spanish physician and martyr, *Miguel Serveto* [1511–1553], in his *De Restitutione Christianismi*.

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"Ovum esse primordium commune omnibus Animalibus" (subsequently expressed by the aphorism "Omne Vivum ex Ovo"), that was announced in his *Exercitationes de Generatione Animalium* (London, 1651). No. 36.

Secondly the discovery of the Lymphatic System by GASPARD ASELLI [c.1581-1626] and OLAUS RUDBECK [1630-1702].

THESE discoveries were followed by the investigations of the intimate structures of Animals and Plants made by a group of eminent contemporary naturalists, with the aid of the then new instrument, the Microscope.

ROBERT HOOKE [1635-1703], the versatile Curator of Experiments to the Royal Society, in 1665, published his *Micrographia*, a work in which the author intentionally touched upon many interesting subjects without working any of them out, content if he furnished the groundwork for others to build on. No. 40.

Among his observations were some of great import. Thus he first saw and named the "cells" in plants, for his subject being a dried cork he naturally judged them empty.

Hooke also studied the minute quartz crystals which he found in the cavity of a flint. Their mode of reflecting and refracting light, with the regularity of their figures, led him to suggest that crystals are built up of spheroids.

To Geology, also, Hooke was an important contributor. Supporting the organic origin of fossils, he explained in his *Lectures and Discourses of Earthquakes* (*Posthumous Works*, 1705), the processes of petrification, inclined towards the extinction of species in some cases and substituted a diluvial theory of his own to account for them, in lieu of the Noachian Deluge.

JAN SWAMMERDAM [1637-1680], a noted Dutch physician and naturalist, specially devoted himself to the study of the anatomy of Insects. His *Historia Insectorum generalis* was published in 1669.

NEHEMIAH GREW [1628-1694], Secretary to the Royal Society, made a number of most careful researches into the Anatomy of Plants that were laid before the Royal Society in a series of papers between the years 1671 and 1677.

Among other things he correctly surmised the true nature

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No. 43.

and functions of the stamens and pistils in flowers, modestly sharing part of the credit with Sir Thomas Millington. Grew, however, did not put his observation to proof. This discovery was announced to the Society in November 1676, but only printed and issued, with the second editions of some previous papers, in his *Anatomy of Plants*, in 1682. Incidentally, from a lecture published in the same volume, it is seen that Minerals were still divided into Earths, Stones, Ores, Metals, Sulphurs, and Salts.

Grew's first paper on the structure of Plants had only just been printed by the Royal Society in 1671, when that body received a communication on the same subject from MARCELLO MALPIGHI [1628–1694], an illustrious Italian physician and naturalist. Malpighi's memoir was then extended, and printed by the Society, in 1675, under the title of *Anatome Plantarum*. In it he gave the earliest account of the circulation of the sap and of the nutrition of plants.

Malpighi had already (1661) confirmed the existence of capillary circulation, that had been inferred by Harvey; had given the first distinct idea of the organization of the lungs; had demonstrated the structure of secreting glands; and made several other important discoveries of a like nature, besides writing on the microscopical structure of Insects.

Nos. 41
& 42.

ANTHONY VAN LEEUWENHOEK [1632–1723], an eminent Dutch naturalist, with rough instruments of his own manufacture, made many interesting and important discoveries, such as the existence of the Wheel-animalcules (*Rotifera*) and their power of enduring desiccation, the mode of propagation of the Green-fly (*Aphis*), and of the development of many Insects: he also reaffirmed Malpighi's discovery of capillary circulation, displaying it in the tail of the tadpole. His observations were mostly communicated in letters to the Royal Society of London from 1673 onwards. These were collected and published in a series of volumes beginning in 1684.

MINERALOGY and Geology received further impetus about this period, mainly through the studies of the following naturalists:—

NICOLAUS STENO [1631–1686], a distinguished Danish

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physician, subsequently Bishop of Titopolis, proposed an hypothesis as to the mode of growth of a Crystal from a primitive nucleus, that included the important discovery of the constancy of the angles of Crystals. He not only maintained the animal origin of the fossil shells, &c., but distinguished between marine and fluvatile formations, and argued in favour of the original horizontality of sedimentary deposits. His treatise, *De Solido intra Solidum naturaliter contento*, promulgating these views, appeared at Florence in 1669. No. 44.

AGOSTINO SCILLA [1639-1700], an Italian painter, also contended for the organic origin of fossils in 1670, illustrating his *Lettera risponsiva circa i Corpi Marini che Petrificati si trovano* by excellent plates, the original drawings for which, with the specimens, were acquired by Dr. John Woodward, and are now at Cambridge. No. 52.

ERASMUS BARTHOLINUS [1625-1698], a Danish geometri-
cian, made known the double-refracting property of Calc-spar in his *Experimenta Crystalli Islandici disdiaclastici*, which appeared in 1670.

CHRISTIAN HUYGENS [1629-1695] studied the laws of double refraction of Iceland Spar and explained them by means of an undulatory theory of light in his *Traité de la Lumière*, Leyden, 1690: he sought to elucidate the peculiar cleavage of this mineral by building up crystals from spheroids, after the manner of Hooke.

THE earliest attempt at a systematic description of the natural history of the whole of Great Britain was by JOSHUA CHILDREY [1623-1670], antiquary, and Archdeacon of Sarum, who in 1661 published his *Britannia Baconica: or the Natural Rarities of England, Scotland, and Wales. According as they are to be found in every Shire*. This was mostly a compilation, and is interesting as showing the state of knowledge at the time, though its chief importance lies in the fact that it appears to have inspired ROBERT PLOT [1640-1696], the first 'Custos' of the Ashmolean Museum, and professor of Chemistry at Oxford, with the idea of extending the scheme and treating each county elaborately. As a specimen he issued a *Natural History of Oxfordshire* in 1677: this was followed by a *Natural* No. 53. No. 55.

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History of Staffordshire in 1686, and he had projected histories of Middlesex and Kent. These were the forerunners of a numerous series of county natural histories by different authors.

Plot's volumes contained original observations and the first record of some English Plants.

Childrey's work may also have prompted the production of SIR ROBERT SIBBALD'S [1641-1722] similar work, *Scotia Illustrata*, that appeared in 1684.

SYSTEMATIC Zoology and Botany were next most considerably advanced by the labours of JOHN RAY, or, as he wrote it before 1669, WRAY [1627-1705], and his friend and co-worker FRANCIS WILLUGHBY [1635-1672]. These two naturalists, dissatisfied with the status of Natural History, agreed to attempt a systematic description of the whole organic world, Willughby undertaking the Animals and Ray the Plants.

No. 46. Ray's *Catalogus Plantarum Angliæ, etc.*, London, 1670, was the first outcome of the travels the two friends had made in company: it enumerated only some 1,050 species, great care having been exercised to exclude varieties. In both this and the second edition, which appeared in 1677, the Plants were arranged in alphabetical order.

No. 50. The early death of Willughby left the whole of the projected undertaking to Ray. He first edited and brought out Willughby's *Ornithologia* in 1676, an English translation following in 1678, and the *Historia Piscium* in 1686. Ray's No. 48. first systematic work on Plants, the *Methodus Plantarum nova*, was produced in 1682, and revised in 1703; in this he foreshadowed the Natural System.

No. 49. Ray's greatest botanical work, the *Historia Plantarum*, the preparation of which had remained in abeyance so long as Robert Morison was engaged on a similar undertaking, was resumed on the latter's death, and came out in 1686-88: it contained descriptions of some 6,900 plants. In 1690 his catalogue of British Plants re-arranged systematically was No. 47. published under the title of *Synopsis Methodica Stirpium Britannicarum*, and gave accounts of some 250 more species than were cited in the *Catalogus*.

To Ray is due both the more accurate definition of

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"species" and the employment of anatomical characters in the definition of the larger groups. Cuvier considered Ray's zoological work "yet more important" than his botanical, it being "the basis of all modern zoology." In geology he followed and improved upon Hooke, while he was one of the first to call attention to the denudation effected by rivers and the sea.

AMONG Ray's contemporaries the following deserve mention :—

MARTIN LISTER [1638–1712], the English naturalist and correspondent of Ray, to whom he sent observations on Plants and on Spiders, of which he was one of the earliest students. His *Historia Animalium Angliæ*, 1678, contains accounts of the Spiders and of the Mollusca, including the fossil shells, which he considered, as Ray did, to be remains of real organisms. From Lister apparently emanated the first suggestion as to the formation of Geological Maps.

No. 51.

ROBERT MORISON [1620–1683], Botanist to Charles II., and afterwards Professor of Botany at Oxford, wrote Pts. ii. and iii. of a *Plantarum Historiæ universalis Oxoniensis*, which appeared in 1680 and 1699, under the editorship of J. Bobart: the first part of the work was never issued. Morison elaborated a system of classification which was apparently largely borrowed from Cæsalpinus.

AUGUST Q. RIVINUS [1652–1723], with whom Ray had some controversy, was also a systematist of note, whose *Introductio generalis in Rem Herbarium* was published, at Leipsic, in 1690, and followed by memoirs on the different orders which he constituted. He suggested that two names should be given to each plant.

JOSEPH PITTON DE TOURNEFORT [1656–1708], a celebrated French botanist, was the practical founder of genera, and therefore in great measure of the present system of classification. His *Éléments de Botanique* came out in 1694: it was afterwards issued in Latin as *Institutiones Rei Herbariæ*. His system of classification was long in vogue on the Continent.

RUDOLPHUS JACOBUS CAMERARIUS [1665–1721], the most celebrated of a family of Tübingen physicians, and a botanist of

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note, furnished the final proof of the sexuality of Plants. His conclusions, based on a long series of careful experiments, were published in the form of a letter to M. B. Valentine, entitled *De sexu Plantarum epistola*, Tübingen, 1694.

ABOUT this period the natural history of the Cape of Good Hope came to be studied, and primarily by WILLEM TEN RHIJNE [c.1600–], physician to the Dutch East India Company, who sent to J. BREYNIUS [1637–1697] some rare plants, of which the latter published a list and description as an appendix to the first century of his *Exotic Plants* in 1678. Rhijne afterwards issued a *Schediasma de Promontorio Bonæ Spei* in 1686.

The Dutch East Indies were investigated by:—

No. 56. GEORG EBERHARD RUMPF [c.1627–c.1706], Consul at Amboina, who made extensive researches and observations. His *D'Amboinsche Rariteitkamer*, published at Amsterdam, 1705, was a distinct advance over previous works on the East Indies: his more important *Herbarium Amboinense*, in 6 parts, edited by Burman, did not appear till 1741–55;

No. 60. FRANÇOIS LEGUAT [1637–1735], the French traveller, who amongst other things in his *Voyages et aventures . . . en deux Isles desertes des Indes orientales*, London, 1708, gives the earliest figure and description of that flightless bird the Solitaire (*Pezophaps solitarius*).

AMONG collectors of note of the period, two call for special mention:—

No. 58. JAMES PETIVER [c.1657–1718], apothecary, was an industrious collector, who formed a miscellaneous museum. He was the first discoverer of many English Plants, and assisted Ray. He also published (1693–1717) descriptions, with illustrations, of specimens in his own collections, or figured in contemporary works. On his death his books and specimens were purchased by Sir Hans Sloane: among them was the copy of Rumpf's *D'Amboinsche Rariteitkamer*, from which Petiver traced the plates for his own *Gazophyllacium*.

No. 56. SIR HANS SLOANE, Bart. [1660–1753], best known as a great collector, and the patron of science, was also author of a

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catalogue of Jamaica Plants, issued in 1696, and of *A Voyage to . . . Madera, Barbadoes . . . and Jamaica, with the natural history of the last*, 1707, 25. No. 61.

The acquisition of his collections by the nation in 1753, and the founding, with them as a basis, of the British Museum, were events that, after a time, exercised no small influence on the development of Natural Science.

GEOLOGY did not make any considerable progress at this time, but JOHN WOODWARD [1665-1728], the geologist and founder of the Museum at Cambridge bearing his name, published in 1695 *An Essay toward a Natural History of the Earth*, from which it is apparent that he recognized the existence of various strata of the Earth's crust, but failed to understand the true disposition of the fossils in them, considering that the whole world had been dissolved at the flood, and that the fossils subsequently settled down in the order of their gravity, the heaviest sinking first. Woodward's *Thoughts and Experiments concerning Vegetation*, read before the Royal Society in 1699 (*Phil. Trans. vol. xxi.*) embody some of the earliest evidences produced of Transpiration in Plants. No. 59.

ANTONIO VALLISNERI [1661-1730], an Italian naturalist, whose works were rich in original observations, ridiculed the theories of Woodward and others in his *Dei Corpi Marini* (Venice, 1721), described the fossils of Monte Bolca, and attempted the first general sketch of the marine deposits of Italy.

THE placing of Cryptogamic Botany on a proper footing at this date was mainly the work of JOHANN JACOB DILLENIIUS [1687-1747], the first Professor of Botany at the University of Oxford, and of his contemporary and rival, the Italian botanist, PIETRO ANTONIO MICHIELI (or MICHELI) [1679-1737]. Both these naturalists, however, erred in their interpretation of the parts of fructification, and the true explanation of these organs was only arrived at many years later by JOHANN HEDWIG [1730-1799].

Dilleniius' chief work, the *Historia Muscorum*, appeared at Oxford in 1741, and his original drawings for some of the

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plates are preserved in the Botanical Department of this Museum. It was the first work printed in England in which any of the Linnean specific characters were exhibited, and was implicitly trusted to by Linnæus, who adopted the species.

AMONG other Naturalists of note living prior to the Natural History Reformation effected by Linnæus, were :—

RENÉ A. FERCHAULT DE RÉAUMUR [1683–1757], the celebrated French natural philosopher and entomologist, whose *Mémoires pour servir à l'Histoire des Insectes*, in 6 vols., Paris, 1734–42, were long the standard work on Entomology.

ALBERT SEBA [1665–1736], the Dutch naturalist, who formed large collections of great worth, of which a remarkable illustrated catalogue, entitled, *Locupletissimi Rerum Naturalium Thesauri accurata descriptio*, was published at Amsterdam in 1734–65.

PETRUS ARTEDI [1705–1735], a young Swedish naturalist and friend of Linnæus, had begun an important work on Fishes, which Linnæus edited and brought out. Artedi's *Ichthyologia*, Lugduni Batavorum, 1738, made some advance towards a natural arrangement; his genera were well constituted and he laid down rules for the nomenclature of genera and species as well as created a precise terminology for all the interior and exterior parts of animals.

GEORGES LOUIS LECLERC, COMTE DE BUFFON [1707–1788], the celebrated French naturalist, who was born the same year as Linnæus, produced a work of descriptive Natural History which was without equal in its time and, by the addition in later editions of the Linnean nomenclature, became a most valuable work and the basis of succeeding works of a like nature for very many years.

JOHAN GOTTSKALK WALLERIUS [1709–1785], a Swedish chemist, who was the first to apply chemistry to agriculture, gave in his *Mineralogia*, Stockholm, 1747, a more complete description of Minerals according to their external characters and a better classification than any before published, basing it on a critical comparison of those that preceded.

AXEL FREDRIC CRONSTEDT [1722–1765], a Swedish chemist and mineralogist, first made use of the blow-pipe in the deter-

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mination of Minerals. He also laid the foundations, in his *Försök till Mineralogie*, Stockholm, 1758, of the modern system of Mineralogy ; he classified the "Stones," which included the "Earths," according to their composition as calcareous, siliceous, argillaceous and so forth.

IT will be seen, therefore, that by the time of Linnæus the outlines of the several Natural Sciences, as now recognised, had begun to be manifest, and the one thing wanting to enable further and more substantial progress to be made was the introduction of method into their study. This Linnæus was successful in supplying. Arrangement with him amounted to a passion, and he delighted in devising classifications. He enunciated the true principles for defining genera and species, and this, with his adoption of the simple binomial method of nomenclature, enabled the daily increasing number of new Plants and Animals to be sorted, and provisionally placed, till their true affinities were ascertained.

His necessarily arbitrary classifications have given way to more natural arrangements in all the three kingdoms, but the underlying method has remained and enabled continuous progress to be made down to the present time.

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BRITISH MUSEUM (NATURAL HISTORY).

SPECIAL GUIDES: No. 2.

BOOKS AND PORTRAITS
illustrating the
HISTORY OF
PLANT CLASSIFICATION
exhibited in the
DEPARTMENT OF BOTANY.



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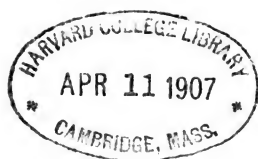
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PREFACE.

THIS Guide has been drawn up to accompany a collection of books and portraits which has been placed in the first recess on the left-hand side on entering the Botanical Gallery. The exhibit represents an attempt to illustrate the chief epochs in the development of a natural system of plant-classification; that is to say a system which shows the actual relationships of plants, as contrasted with an artificial system which is based on the differences presented by one set of organs.

A. B. RENDLE.

BRITISH MUSEUM
(NATURAL HISTORY),
July, 1906.

HISTORY OF PLANT CLASSIFICATION.

DIOSCORIDES [born about A.D. 40].

MATERIA MEDICA.

AN EXAMPLE of the botany of the classic period. Theophrastus, Pliny and Dioscorides knew of a considerable number of plants, to which they referred as herbs, shrubs, trees, fruits, cereals, or in similar terms indicating their general manner of growth or use to man. They had no system of classification, but gave a short general description of each plant, and an account of its medicinal use and virtues.

The volume shown is the first printed edition in the original Greek from the press of Aldus Manutius at Venice, dated 1499. The plates described are—on the left page, *Peucedanum* and *Nigella* (called *Melanthium*), on the right, *Silphium*.

There is little or nothing to record in the way of progress from the time of the classic writers to that of the botanical renaissance represented in the earlier German Herbals.

“ORTUS SANITATIS.” Mainz, 1475.

A book on general natural history containing very crude descriptions and wood-cuts of the plants, which frequently indicate little or no acquaintance with the object treated. No definite order is observed.

Many editions were published in various languages. The volume shown is an early Latin edition.

The fact that a work of so low a standard was generally accepted and widely used, suggests a general abeyance of the powers of observation in the study of plants.

History of Plant Classification.

OTTO BRUNFELS.

HERBARIUM. Strassburg, 1530-36.

An early example of the Herbals of the sixteenth century, from which dates the scientific study of plants. They contain figures and descriptions from actual specimens; a botanical terminology gradually appeared; and plants which, like the Orchids, have a strong general likeness, were grouped together. The woodcuts are excellent examples of their kind.

Otto Brunfels, the son of a cooper at Castle Brunfels near Mainz, was born at that town about 1488. At first a Carthusian monk, he became a convert to Protestantism and went to Strassburg, where he opened a school; but later became a physician and removed to Berne, where he died in 1534.

WILLIAM TURNER.

HERBAL: Part 1, London, 1551; Part 2, Cologne, 1562.

Turner, who has been called the Father of English Botany, was the author of several botanical works. The arrangement of each part of his Herbal is alphabetical. The woodcuts are much inferior to those of Brunfels' Herbarium.

William Turner, a militant protestant divine and the author of various controversial works, was born about 1512 and educated at Pembroke College, Cambridge, of which he became Fellow (1531) and Treasurer (1538). His first botanical book, *Libellus de re Herbaria novus*, was issued in 1538. His zeal for the reformed religion led to his banishment by Henry VIII., after whose death he returned and became Dean of Wells (1550). He again left England on Mary's accession, but returned in the next reign. Suspended for non-conformity in 1564, he came to London, where he died in 1568, in which year was published at Cologne a new edition of his Herbal containing a third part.

History of Plant Classification.

JOHN GERARD.

HERBAL OR GENERALL HISTORIE OF PLANTES. London, 1597.

The most important of the British Herbals. The page shown gives a good illustration of the method of arrangement which was evolved by the herbalists. Gerard adopted the arrangement of L'Obel, whose *Plantarum seu Stirpium Historia* was published at Antwerp in 1576. The groups recognized are based on well-marked characters of general form, manner of growth and economic use; there is a total neglect of characters of fruit and seed. The general scheme starts with what were supposed to be the simpler forms—grass-like plants with narrow leaves—and advances through the broader-leaved bulb- and rhizome-bearing Monocotyledons to dicotyledonous herbs, culminating in shrubs and trees, the latter being regarded as the most perfect.

The volume shown is the second edition, edited by Thomas Johnson (1633).

John Gerard was born at Nantwich in 1545, and educated locally. He became a barber-surgeon in London, where he had a garden near Holborn; in 1596 he published a catalogue of the plants cultivated therein, probably the first complete published catalogue of any one garden. His Herbal was based on Dodoens' *Stirpium Historiæ Pemptades* (Antwerp, 1583); the blocks were those used by Tabernaemontanus in his *Icones* (1590), with a few original additions. Gerard died in London in 1612.

CASPAR BAUHIN.

PRODROMUS THEATRI BOTANICI. Frankfort, 1620.

A high stage of precision is reached in Caspar Bauhin's *Prodromus* and *Pinax* (1623). The general arrangement is still on the primitive lines seen in L'Obel and Gerard, but the descriptions are more scientific, and omit the medicinal detail which figured so prominently in earlier works.

Bauhin was born at Basle in 1550. He was a pupil of Leonhard Fuchs, collected plants in Italy, France and Switzerland, and became Professor at Basle. He died in 1624.

History of Plant Classification.

ANDREA CESALPINO.

DE PLANTIS. Florence, 1583.

Cesalpino studied the arrangement of plants from a philosophical point of view. He concluded that a natural classification must be based on the characters of fruit, seed and embryo, but still recognized the two main divisions into woody and herbaceous plants, and his method is no improvement on that adopted by the later herbalists. Cesalpino gives no general review of his system, which, however, is given by Linnæus in his *Classes Plantarum*.

The volume shown is of interest as having been the property of Marcello Malpighi (1628–1694), one of the earliest workers on plant anatomy.

Cesalpino was born at Arezzo in Tuscany in 1519, and studied under Ghini, director of the public garden at Pisa, in the university of which town he became professor of medicine and anatomy. He was afterwards chief physician to Pope Clement VIII., and died at Rome in 1603. He wrote numerous anatomical works, and to some extent anticipated Harvey's discovery of the circulation of the blood.

ROBERT MORISON.

PLANTARUM HISTORIA UNIVERSALIS. Oxford, 1680.

Morison's system much resembles that of Cesalpino. Woody plants are kept distinct from herbaceous; the latter are divided into fifteen sections based partly on habit, partly on characters derived from fruit and seed. The improved arrangement and the introduction of tables renders the material more available than it was under the old arrangement of books and chapters. In Morison's works copper-plates take the place of the woodcuts of the old Herbals.

History of Plant Classification.

ROBERT MORISON.

PLANTARUM UMBELLIFERARUM DISTRIBUTIO NOVA.

Oxford, 1672.

The first systematic monograph of a limited group. The arrangement is based on the form of the fruit.

Robert Morison was born at Aberdeen in 1620, and studied in that University, and afterwards in Paris, taking the degree of doctor of physic at Angers in 1648. From 1650-60 he was in charge of the Duke of Orleans' garden at Blois. Returning to England at the Restoration, he was appointed King's Physician and Royal Professor of Botany, and in 1669 Keeper of the Physic Garden, Oxford, an appointment which he held until his death from an accident in a London street in 1683.

JOHN RAY.

HISTORIA PLANTARUM. London, 1686-1704.

By his recognition of the importance of the character of the embryo and the presence of one or two cotyledons, Ray inaugurated a natural system of classification. The old division into Herbs and Trees is retained.

Herbæ	{	Imperfectæ (flowerless).	{	Dicotyledones.
		Perfectæ (flowering)		Monocotyledones.
Arbores	{	Monocotyledones.	{	
		Dicotyledones.		

The ultimate division is into thirty-three Classes, some of which are natural groups, such as Fungi, Umbelliferæ, Stellatæ (Rubiaceæ), Verticillatæ (Labiatæ), Leguminosæ, Stamineæ (Grasses); many of these had been recognized by previous writers.

In his arrangement of the Classes Ray made use of characters afforded by the fruit and flower, as well as by other parts of the plant.

John Ray was born at Black Notley, Essex, November 29, 1627, and was educated at Braintree and Cambridge University, becoming Fellow of Trinity College in 1649, and subsequently holding various appointments at the same college. In 1660 he

History of Plant Classification.

issued his Catalogue of Cambridge Plants. With his friend and pupil, Francis Willughby, he made several journeys in Great Britain for the study of natural history ; and, having been deprived of his Fellowship in 1662 for refusal to subscribe to the new Act for Uniformity, undertook a longer tour on the continent of Europe from 1663 to 1666. In 1670 he published his Catalogue of English Plants, and in 1682 his *Methodus Plantarum Nova*, wherein he proposed the system of plant classification, which, with some improvements, he adopted in the *Historia Plantarum*. Of this great work, the first volume (here shown) appeared in 1686, the second in 1687, and the third, a supplement, in 1704.

Ray published other works on natural history ; among these is an account of experiments, with Francis Willughby, on ascent and descent of sap in trees. He settled at Black Notley in 1679, and died there in 1705.

JOSEPH PITTON DE TOURNEFORT.

INSTITUTIONES REI HERBARIÆ. Paris, 1700.

Tournefort's System was based on the characters of one organ, the corolla, and was therefore an artificial one, thus comparing unfavourably with that of Ray, though many of the classes are identical. The chief merit of Tournefort's work is his accurate definition of genera.

J. P. de Tournefort was born at Aix in Provence in 1656. At first a student of theology, his love of plants led him to science ; he studied anatomy and medicine at Montpellier and made botanical journeys in South France and Spain. In 1683 he was appointed Professor of Botany at the Jardin des Plantes, Paris. In 1694 appeared his *Elemens de Botanique*, of which the *Institutiones* is an enlarged Latin edition. For some of his views on genera he was attacked by Ray. He was sent in 1700 on a voyage of scientific exploration to Greece and Asia Minor, and returned in 1702 with large natural history collections, including 1,356 new species of plants. The work of describing his collections, joined to his professorial and medical duties, proved too arduous ; his health gave way, and he died in 1708.



CARL LINNÆUS.

From the portrait by Roslin at Stockholm.

History of Plant Classification.

CARL LINNÆUS.

SYSTEMA NATURÆ. Leyden, 1735.

Linnæus recognized twenty-four Classes, determined mainly by the number or some obvious character of the stamens; the Classes are divided into Orders according to the number of the styles. Although an artificial system, based on one set of organs, its convenience led to its universal adoption; it was known as the Sexual System.

Carl Linnæus was born at Rashult, a small village in Smaland, Sweden, May 23, 1707. His father was rector of a neighbouring parish. From his boyhood Linnæus showed a love for plants, but his literary studies made little progress. In 1727 he entered the University of Lund, for the study of medicine, but removed the next year to Upsala, where, in 1730, he was put in charge of the botanic garden as assistant to Professor Rudbeck. In 1732 he made a tour through Lapland. In 1735 he went to Holland and obtained his doctor's degree, and made the acquaintance of George Clifford, who engaged Linnæus to study and superintend the large collection in his garden at Hartecamp. The *Hortus Cliffortianus*, an account of the plants in Clifford's collection, appeared in 1737; the herbarium upon which this book is based became afterwards the property of Sir Joseph Banks, and thus passed to the Department of Botany, British Museum. In Holland the *Systema Naturæ* was published (1735), and other works, including the *Genera Plantarum* (1737) and the *Classes Plantarum* (1738). Linnæus visited England in 1736. In 1738 he returned to Stockholm, and practised medicine till, in 1741, he became Professor at Upsala, where he spent the remainder of his life. In 1753 he published the *Species Plantarum*, from which dates the binominal system of nomenclature, in which a plant is designated by two words, the name of the genus, e.g. *Rosa*, followed by a specific name, e.g. *canina*. Linnæus died in 1778.

History of Plant Classification.

GEORG DIONYSIUS EHRET.

PLATE ILLUSTRATING THE SEXUAL SYSTEM.

This famous botanical artist and friend of Linnæus published a plate illustrating the Classes of the Sexual System, of which this is the original.

CARL LINNÆUS.

PHILOSOPHIA BOTANICA. Stockholm, 1751.

Linnæus, in his *Classes Plantarum* (1738), sketched out a natural system, which appears in a revised form in the *Philosophia*. Genera are arranged in sixty-eight Orders, based not on one character but on his idea of their relationships, depending, as Linnæus expressed it, on the simple symmetry of all parts. He gives no diagnoses of the Orders, many of which had been recognized by Ray and others; some are natural groups, while others are more or less mixed.

MICHEL ADANSON.

FAMILLES DES PLANTES. Paris, 1763.

This work contains an exhaustive account of previous systems, and an arrangement of genera in fifty-eight Families, which are named and characterized.

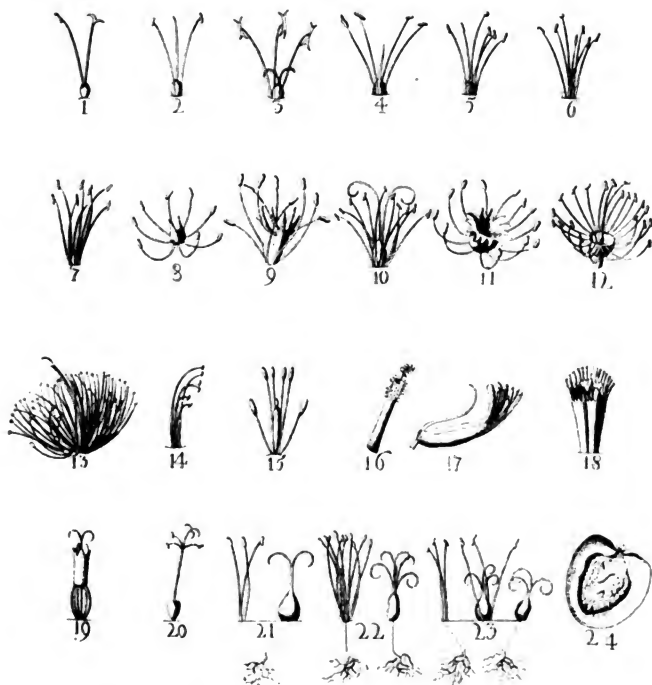
Michel Adanson was born at Aix in Provence in 1727, and studied medicine, botany and astronomy at Paris, where he was a pupil of Reaumur. In 1748 he went to Senegal, and spent six years in studying the geography, climate and natural history of that part of west tropical Africa; the results of his observations were published in his *Histoire naturelle du Senegal*. He died in 1806, and is commemorated in the genus *Adansonia*, the Baobab.

ANTOINE LAURENT DE JUSSIEU.

GENERA PLANTARUM. Paris, 1789.

The Natural System of Linnæus was developed by the Jussieus. Bernard de Jussieu used it, with modifications, in his arrangement of the plants in the Trianon, and his nephew

CAROLI LINNÆI CLASSES S. LITERÆ.



EHRET'S PLATE ILLUSTRATING THE 24 CLASSES OF
THE SEXUAL SYSTEM.

History of Plant Classification.

Antoine further improved it. The latter defined 100 Natural Orders, and arranged them in a system of fifteen Classes under the great groups suggested by Ray—Acotyledones, Monocotyledones and Dicotyledones. The Dicotyledones were subdivided into Apetalæ, Monopetalæ, Polypetalæ and Diclinal Irregulares.

A. L. de Jussieu was born at Lyons in 1748. In 1765 he went to Paris to finish his medical and scientific studies under the direction of his uncle, Bernard de Jussieu, who was in charge of the Royal Garden, and from 1770 to 1785 continued the work of rearrangement begun by his uncle. On the organization of the Museum d'Histoire Naturelle in 1793 he became Professor of Rural Botany, and subsequently held the offices of director and treasurer of the administration of the Museum. He published numerous carefully elaborated memoirs on genera and families of Dicotyledons, and died in 1836.

AUGUSTIN PYRAMUS DE CANDOLLE.

THÉORIE ÉLÉMENTAIRE DE LA BOTANIQUE.

Ed. ii., Paris, 1819.

A. P. de Candolle showed that the relationships of plants are ascertained by the comparative study of the form and development of organs (morphology), not of their functions (physiology), and thus defined the principles of a natural system. He suggested the following arrangement :—

I. Vascular plants or plants with cotyledons.

1. Exogens or Dicotyledons.

- | | | |
|---------------------------------------|---|---|
| a. With distinct calyx
and corolla | { | Thalamifloræ (petals free and hypogynous). |
| | | Calycifloræ (petals perigynous or epigynous). |
| | | Corollifloræ (petals united and hypogynous). |

History of Plant Classification.

b. Monochlamydeæ, with a single perianth whorl (including Coniferæ).

2. Endogens or Monocotyledons.

a. Phanerogams (including Cycadeæ).

b. Cryptogams.

II. Cellular plants or plants without cotyledons.

a. Foliaceous and of known sexuality (Mosses and Liverworts).

b. Without leaves and of unknown sexuality (Lichens, Fungi, Algæ).

The general arrangement of Dicotyledons is improved, but in the inclusion of Vascular Cryptogams among Monocotyledons the arrangement is inferior to that of Jussieu.

A. P. DE CANDOLLE.

PRODROMUS SYSTEMATIS NATURALIS REGNI VEGETABILIS.

Paris, 1824-1873.

A descriptive account of all the species of Dicotyledons and Gymnosperms known when the volumes were published, and perhaps the most important factor in the development and general adoption of the Natural System. Most of the Orders were elaborated by de Candolle and his son Alphonse, who continued the work after his father's death.

Augustin Pyramus de Candolle was born at Geneva in 1778, where he spent his boyhood. From 1798 to 1808 he was in Paris, where he associated with the prominent French naturalists and published various botanical works, including a new edition of Lamarck's *Flore Française*. In 1808 he became Professor of Botany at Montpellier, where he remained till 1816. During this period he made botanical journeys in France and neighbouring countries, and wrote many botanical works, including his famous *Théorie élémentaire*. In 1816 he visited England, whence he returned to Geneva, where he resided till his death in 1841.



ROBERT BROWN.

From the portrait at the Linnean Society.

History of Plant Classification.

ROBERT BROWN.

PRODROMUS FLORÆ NOVÆ HOLLANDIÆ. London, 1810.

A description of Australian plants, mainly those collected by Banks and Solander in Cook's Voyage (1768-71) and by Brown himself (1802-5): together with important observations on the affinities of Orders, several of which (*e.g.*, Santalaceæ, Stylidiæ) are here established for the first time.

ROBERT BROWN.

THE FEMALE FLOWER IN CYCADEÆ AND CONIFERÆ, 1827.

This paper announces the important discovery of the distinction between Angiosperms and Gymnosperms. By his investigation of difficult points in the morphology of the flower and seed, and his critical work on affinities, Brown ranks high as an exponent of the Natural System, though he published no general scheme of arrangement. The philosophical character of his work and its important bearing on many departments of Botany, led Humboldt to distinguish him as "*botanicorum facile princeps.*"

Robert Brown was born at Montrose in 1773, and was educated at Aberdeen and Edinburgh Universities. In 1801, at the instance of Sir Joseph Banks, he went as naturalist to the expedition under Captain Flinders to Australia, and returned in 1805 with a large collection of plants, representing nearly 4,000 species. In 1810 he became librarian to Sir Joseph Banks, who (on his death in 1820) bequeathed to Brown for life the use of his library and collections. In 1827 these were transferred to the British Museum, and Brown became Keeper of the Banksian (or Botanical) Department, a post which he held till his death in 1858.

History of Plant Classification.

JOHN LINDLEY.

INTRODUCTION TO THE NATURAL SYSTEM OF BOTANY.

London, 1830.

A slight modification of de Candolle's arrangement, with the apetalous and polypetalous Dicotyledons united in one section.

John Lindley was born in 1799 near Norwich, and was educated at the Grammar School in that town. In 1819 he became assistant librarian to Sir Joseph Banks, and was associated with the Horticultural Society from 1822 to 1858. From 1829 till 1861 he filled the Chair of Botany at University College, London. He was the author of numerous works on Botany and Horticulture, including the *Vegetable Kingdom* (1846), a general treatise, and was especially devoted to the study of Orchids. He died in 1865.

STEPHAN ENDLICHER.

GENERA PLANTARUM. Vienna, 1836-40.

Endlicher's system, which has been widely used on the Continent, shows an advance in the treatment of the Cryptogams, which are placed first and arranged in a fairly natural sequence. The chief defects are the rank assigned to Gymnosperms, and the inclusion of the Cycads and some parasitic flowering plants with the Cryptogams. The names for the three sections of Cormophyta are based on wrong ideas of growth.

Stephan Ladislaus Endlicher was born at Presburg in 1804. He had a theological education, but subsequently devoted himself to Natural History, and in 1836 became Keeper of the Herbarium in the Imperial Collections of Natural History at Vienna, where, in 1840, he succeeded Jacquin as Professor of Botany and Director of the Botanic Garden. He died in 1849.

History of Plant Classification.

WILHELM HOFMEISTER.

ON THE HIGHER CRYPTOGAMIA AND CONIFERÆ.

Leipzig, 1851.

The volume shown is the English revised edition published by the Ray Society, 1862.

Hofmeister's brilliant embryological researches threw much light on the relationship of the groups of Cryptogams to each other and to the Phanerogams, and indicated the position of the Gymnosperms between the higher Cryptogams and the Angiosperms. It supplies the basis for the distinction of the now generally recognized great plant groups—Thallophyta, Bryophyta, Pteridophyta, Gymnospermæ, and Angiospermæ. Recent investigations of fossil plants have brought to light an intermediate group—Cycadofilices—between Ferns and Gymnosperms, with the habit and foliage of Ferns, but bearing structures closely resembling the seeds of the higher plants.

Wilhelm Hofmeister was born in 1824 at Leipzig. Though a self-taught botanist and engaged in business, he attracted attention at an early age by his fundamental observations on the comparative embryology of the great plant-groups. In 1863 he was called to the Chair of Botany at Heidelberg, and in 1872 succeeded Hugo von Mohl at Tübingen University. He died in 1877.

GEORGE BENTHAM & JOSEPH DALTON
HOOKER.

GENERA PLANTARUM. London, 1862–1883.

The system of Bentham and Hooker, by which the herbaria here and at Kew are arranged, replaces Endlicher's book as a systematic and descriptive account of genera. It is based on that of de Candolle, and deals only with the Phanerogams.

History of Plant Classification.

George Bentham was born in 1800 at Stoke, near Plymouth. His early life was spent in France, where he devoted much of his leisure to botany. Returning to England in 1826, he spent a few years reading for the Bar and in arranging for the press the works of his uncle, Jeremy Bentham. From 1832 until his death in 1884, he devoted the greater part of his time to botanical work, chiefly the systematic study of genera and families, or the study of floras; he was also the author of the important *Flora Australiensis* (1863-78). He was President of the Linnean Society from 1861 to 1874.

Sir Joseph Dalton Hooker, born in 1817, is the son of Sir William Hooker, whose name will always be associated with the development of the Royal Gardens, Kew. His life has been devoted to botany: as an explorer, in the Antarctic Regions (which he visited as botanist to Sir James Ross's expedition, 1839-43), in the Himalayas, in the Atlas Mountains, and elsewhere; as an administrator, in connection with the Royal Gardens, Kew, where he succeeded his father as Director (1865-1885); and as the author of numerous and important systematic and morphological works.

AUGUST WILHELM EICHLER.

SYLLABUS. Berlin, 1883.

This system has been widely used on the Continent. Eichler united the apetalous and polypetalous sub-classes or Dicotyledons, the Orders of which he attempted to arrange in a series advancing from the primitive to the most highly developed.

A. W. Eichler was born at Neukirchen in 1839, and studied mathematics and natural history at Marburg. In 1861 he went to Munich to assist Martius in the preparation of the *Flora Brasiliensis*, of which he became sole editor after Martius's death in 1868. He occupied successively the Chairs of Botany at Munich, Graz, Kiel, and Berlin. Eichler's chief original work was the well-known *Blüthendiagramme* (1875-8); he died in 1887.

History of Plant Classification.

ADOLF ENGLER.

SYLLABUS DER PFLANZENFAMILIEN. ed. iii., Berlin, 1903.

This represents the latest and most generally accepted view on plant classification. The arrangement of Phanerogams is based on Eichler, and is followed in this gallery.

Dr. Adolf Engler, born in 1844, has been successively Custos of the Botanical Museum at Munich, Professor of Botany and Director of the Botanic Garden at the Universities of Kiel and Breslau, and, since 1889, Professor of Botany and Director of the Botanic Garden and Museum at Berlin. He is the principal editor of the most recent general work on systematic botany, *Die Natürliche Pflanzenfamilien* and the editor of the *Pflanzenreich*, a series of monographs of the families of Flowering Plants; he is also the author of numerous papers on systematic and geographical botany.

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BRITISH MUSEUM (NATURAL HISTORY)

SPECIAL GUIDES No. 3

MEMORIALS OF LINNÆUS

A COLLECTION OF PORTRAITS MANUSCRIPTS
SPECIMENS AND BOOKS EXHIBITED TO
COMMEMORATE THE BICENTENARY
OF HIS BIRTH



LONDON
PRINTED BY ORDER OF THE TRUSTEES
OF THE BRITISH MUSEUM

1907

[PRICE THREEPENCE]



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BY

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6



CARL LINNÆUS
From the original by P. Krafft

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PREFACE

THIS Guide has been drawn up to accompany a collection of portraits, autographs, manuscripts, specimens and books, which has been arranged by order of the Trustees in commemoration of the bicentenary of the birth of Linnæus. These memorials of Linnæus are exhibited in three cases in the second botanical bay on the east side of the Great Hall. The fine series of autograph letters and manuscripts is from the Department of Manuscripts, and has been prepared for exhibition by the Keeper, Dr. G. F. Warner. The large portrait of Linnæus in Lapland costume and the portrait of Dr. Solander are from the Department of Prints and Drawings. For the loan of the specimens and books from Linnæus's own collection we are indebted to the courtesy of the President and Council of the Linnean Society ; without this help the exhibition would have been far less interesting. To Dr. William Carruthers, formerly Keeper of the Department of Botany, we owe the fine series of portraits of Linnæus. The remaining exhibits are from the Department of Botany, which contains several early collections associated with Linnæus.

A. B. RENDLE.

DEPARTMENT OF BOTANY,
BRITISH MUSEUM (NATURAL HISTORY),
July, 1907.

MEMORIALS OF LINNÆUS

CARL LINNÆUS was born at Rashult, a small village in Smoland, Sweden, May 23, 1707. His father was rector of a neighbouring parish. From his boyhood Linnæus showed a love for plants, but his literary studies made little progress. In 1727 he entered the University of Lund, for the study of medicine, but removed the next year to Upsala, where, in 1730, he was put in charge of the botanic garden as assistant to Professor Rudbeck. In 1732 he made a tour through Lapland. In 1735 he went to Holland and obtained his doctor's degree, and made the acquaintance of George Clifford, a wealthy banker, who engaged Linnæus to study and superintend the large collection in his garden at Hartecamp. The *Hortus Cliffortianus* (exhibited in the third case), an account of the plants in Clifford's collection, appeared in 1737. In Holland were published the *Systema Naturæ* (1735) and other works, including the *Genera Plantarum* (1737) and the *Classes Plantarum* (1738).

Linnæus came to England in 1736, bringing a letter of introduction (which is exhibited) from Boerhaave, Professor of Botany at Leyden, to Sir Hans Sloane. He visited the Chelsea Botanic Garden, then under the charge of Philip Miller, and the Oxford Botanic Garden, where he spent some time with Dillenius, the Professor of Botany.

In 1738 he returned to Stockholm, and practised medicine till, in 1741, he became Professor at Upsala, where he spent the remainder of his life. In 1753 he published the *Species Plantarum*, from which dates the binominal system of plant nomenclature; a volume is exhibited in the second case. Linnæus died in 1778.

On the right and left of the bay are two portraits of

Memorials of Linnæus

Linnæus. That on the right is a mezzotint reproduction of a replica, painted in 1739, of the portrait of Linnæus in Lapland costume (see below). The engraving differs in several points from the original portrait. The replica came into the possession of Dr. Robert Thornton towards the end of the eighteenth century; the reproduction was used for a plate in his book entitled *A New Illustration of the Sexual System of Carolus von Linnæus*, published in 1807. The right hand holds a specimen of *Linnæa*, and the left an oval object, which is apparently a press for drying plants; gloves, drinking-horn and various other implements hang from an ornamented leather girdle. On a column behind are placed eight volumes of Linnæus's works.

The portrait on the left is a reproduction from the painting by Per Krafft, 1774, now at the Royal Swedish Academy of Sciences, Stockholm.

FIRST CASE

SERIES OF PORTRAITS OF LINNÆUS

(Presented by Dr. William Carruthers, F.R.S.)

1 IN LAPLAND DRESS, 1737. A photograph of the original painting by Martinus Hoffman, at Hartecamp, near Haarlem, for George Clifford (see *Hortus Cliffortianus* in second case), and now in the possession of Mr. Clifford of Nieuwersluys, Holland.

2 AS A BRIDEGROOM, 1739. A photograph of the original painting by the Swedish portrait painter J. H. Scheffel, in Linnæus's house at Hammarby, near Upsala. Linnæus was married in June, 1739, to Sarah Elizabeth Moræus.

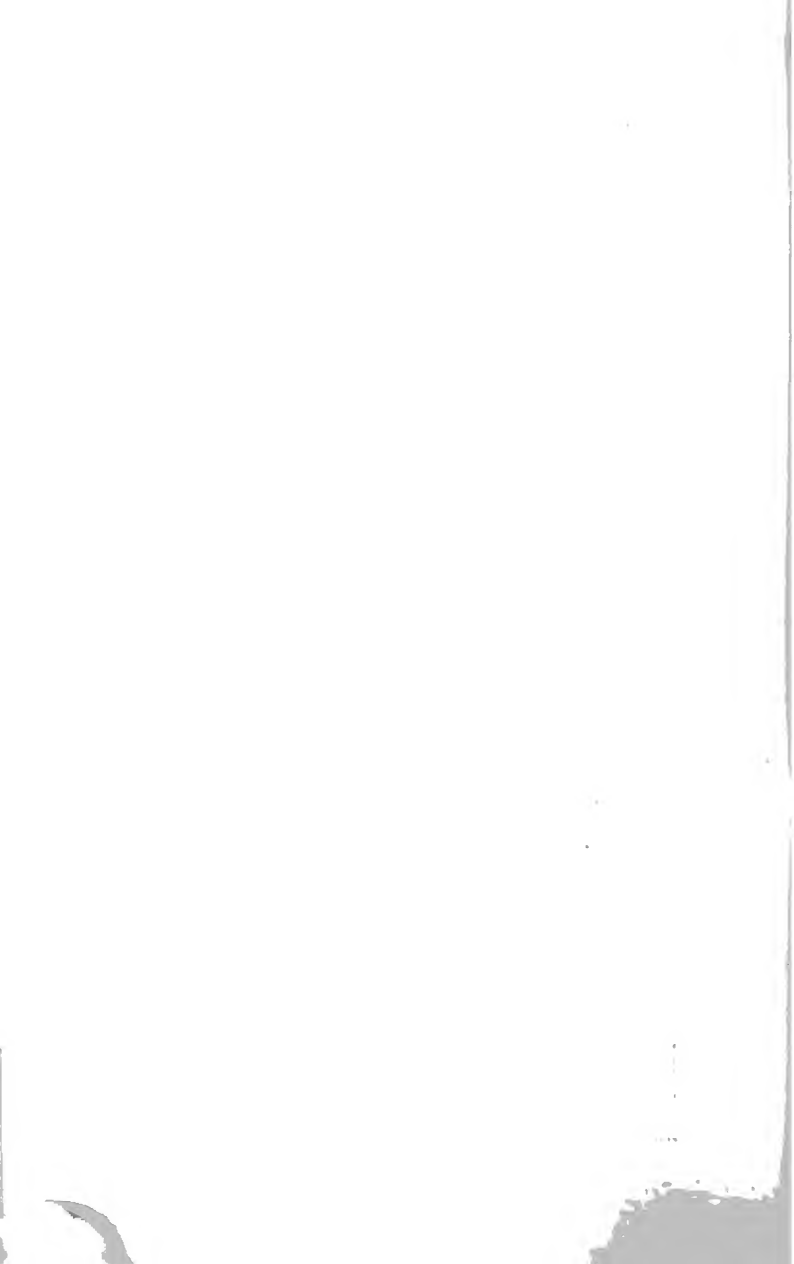
3 FROM THE ENGRAVING by Augustus Ehrensverd, 1740. The photograph is reversed. One hand rests on a volume labelled on the back "Syst. Nat.," the other holds a sprig of *Linnæa*. On the left shoulder is an academic gown which comes in folds below the right arm.

4 IN EVERY-DAY DRESS, 1747. From the lithograph of a sketch by J. E. Rehn.



LINNAEUS IN LAPLAND DRESS

From the original by M. Hoffman



Memorials of Linnæus

5 **PROFILE, 1747.** From a lithograph which is said to be the facsimile of a drawing from nature by J. E. Rehn, the original of which is unknown.

6 **IN COURT DRESS, 1752.** A photograph of the original pastel by Gustaf Lundberg, painter to the Swedish Court; the original is now in the possession of Mr. Olof Wijk, Gothenburg.

7 **A PHOTOGRAPH** of the original painting by J. H. Scheffel, 1755, in Linnæus's house at Hammarby. The right hand holds a sprig of *Linnæa*; the Cross of the Polar Star is attached to the coat.

8 **A PHOTOGRAPH** of the medallion by Carl Fridr. Inlander, 1773. The original medallion is in Linnæus's house at Hammarby, but Inlander produced two replicas, one of which was presented to the Linnean Society by Sir Joseph Banks in 1790. It shows the *Linnæa* and the Cross of the Polar Star.

9 **A PHOTOGRAPH** of the original painting by Per Krafft, 1774, for the College of Physicians in Stockholm, now at the Royal Swedish Academy of Sciences, Stockholm. The left hand holds the *Linnæa* and partly covers the Cross of the Polar Star.

10 **A PHOTOGRAPH** of the original painting by Alexander Roslin, 1775, at the Royal Swedish Academy of Sciences, Stockholm.

AUTOGRAPH LETTERS AND MANUSCRIPT

1 **AUTOGRAPH** in the album of — Schütze, dated Upsala, October 9, 1751. The quotation "*Famam extollere factis*" (Virgil, *Aen.* x. 468) was the keynote of his life, and occurs again at the end of the list of his works and also on the fly-leaf of his autobiography, both here exhibited. A similar phrase occurs in the autograph epitaph exhibited.

2 **AUTOBIOGRAPHY, 1707-1750.** The page exhibited records his birth at one o'clock between May 12 and 13, 1707, his name Carl, his parents Nils Linnæus and Christina Brodersonia. On f. 18 is a list of his works, corresponding with that here exhibited, followed by brief notes of their contents, etc. *Swedish. Autograph.*

Memorials of Linnæus

3 AUTOBIOGRAPHICAL MEMORANDA, 1707–1768. On the loose leaf is the draft of a Latin epitaph, in which he says of himself “fidissimus doctor, acutissimus observator, indefessus scriptor, clarissimus auctor, famam extendebat factis, Naturæ Regnorum reformator, Botanicorum Princeps dictus, sibi plura naturæ miracula visa gloriabatur quam ullo alio mortalium.” *Swedish. Autograph.*

4 LIST OF WORKS, 1735–1774. Prefixed are the lines, “Haec non sola mihi patefecit opinio famae | vulgaris, quaesita Libris, nec Lectio priscis | sed Labor et studium, quibus otia longa dierum | postposui,” and appended is his favourite quotation. Several of these works are shown in the second case, including the first on the list, a dissertation on the Cause of Intermittent Fevers submitted for his degree of M.D. at the University of Harderwyk, 1735. *Autograph.*

5 “CORRESPONDENTES EXTERI.” An alphabetical list of his foreign correspondents, among them Sir Hans Sloane, J. J. Dillenius, Professor of Botany at Oxford, and other English men of science. *Autograph.*

6 LETTER FROM HERMAN BOERHAAVE, Professor of Botany at Leyden, to Sir Hans Sloane, introducing Linnæus, beginning “Linnæus has Tibi tradit, unice dignus Te videre, dignus a Te videri : qui vos simul videt, cernet hominum par, cui aliud simile orbis vix dabit” ; Leyden, 17 $\frac{18}{7}$ 36 (18 July, 1736). *Latin. Autograph.*

7 LETTER FROM LINNÆUS to Sir Hans Sloane, thanking him for the use of his museum, “quod Tuum incomparabile Museum mihi, quoties accessi, aperire numquam deliberasti,” and transmitting a small work of his own ; Amsterdam, 21 Jan., 1737. *Latin. Autograph.*

Sir Hans Sloane (1660–1753), a wealthy physician and patron of science, whose large library and collections passed at his death to the nation, and with the Harleian collection of Manuscripts and the Cottonian Library were the foundation of the British Museum.

8 LETTER FROM LINNÆUS to his pupil Daniel Charles Solander (1736–1782), lately arrived in England, afterwards

Memorials of Linnæus

Keeper of the Natural History Department at the British Museum. (See portrait in third case.) The latter part of the letter relates to various flowers, *Belladonna*, *Gardenia*, etc. ; Upsala, 1 Jan., 1762. *Swedish. Autograph.*

9 LETTER FROM LINNÆUS to Emanuel Mendes da Costa, F.R.S., the well-known conchologist, acknowledging the receipt of his book [*A Natural History of Fossils*. Vol. I., part I., 1757] ; Upsala, 27 Feb., 1759. *Latin. Autograph.*

10 LETTER FROM LINNÆUS to Philip Miller (1691-1771), gardener of the Physick Garden of the Apothecaries' Society at Chelsea (1722-1770), concerning the *Æstrum lapponum*, an insect which attacks the reindeer in Lapland ; 10 Nov., 1737. *Latin. Autograph.*

Miller's herbarium, illustrating his *Gardeners Dictionary*, was purchased by Sir Joseph Banks in 1774 and is now in the Department of Botany.

11 LETTER FROM LINNÆUS to Antoine Gouan, Professor of Botany at Montpellier, describing the flowers he sees from his window, etc. ; Upsala, 1 Sept., 1765. *Latin. Autograph.*

12 LETTER FROM LINNÆUS to Gouan, concerning various plants ; circ. 1765 ? *Latin. Autograph.*

13 "CAROLI LINNAEI PAN SUECICUS." Tables of plants accepted or rejected as food by different classes of animals ; by Nicholas L. Hesselgren, with additions by Linnæus. *Autograph.* The letters at the heads of the columns stand for *boves*, *caprae*, *oves*, *equi*, *sues*.

14 DESCRIPTIONS OF SOME ANIMALS AND PLANTS. *Latin. Autograph.*

15 THREE ACADEMIC DISSERTATIONS by various authors with notes in Linnæus's hand ; lent by the Linnean Society from the Library of Linnæus :—

THE GUINEA-PIG (*Mus indicus*), Upsala, 1754 ; Linnæus has altered the name to *Mus Porcellus*, as it appears in the reprint in his *Amoenitates Academicæ* (also shown) : THE MIGRATIONS OF BIRDS, Upsala, 1756 : FLORAL CALENDAR, Upsala, 1756.

Memorials of Linnæus

THE LINNEAN COLLECTIONS

Linnæus acquired by his own collecting, and by correspondence with other collectors and scientific men, a large number of plants, insects, shells, minerals, &c., for which he built, in 1769, a Museum at his country place at Hammarby. The value of the specimens is much enhanced by the numerous works on systematic botany and zoology which he published, and for which they were to some extent the basis. After his death in 1778 they became the property of his son, who made considerable additions, especially to the herbarium. He died in 1783, and the collections were then offered to Sir Joseph Banks for the sum of one thousand guineas. Banks, who had already a very large herbarium, was not inclined to acquire them, but urged his friend James Edward Smith, a young medical man who was much interested in botany, to purchase them. With his father's assistance Smith became, in 1784, the possessor of the whole of Linnæus's library, museum and manuscripts, for the sum of nine hundred guineas. The transaction was hurried on from the fear of Linnæus's widow that, on the return of the King of Sweden from abroad, she might be compelled to dispose of them for less money to the University of Upsala. The ship on which they were carried to London had only just sailed when the King returned; a vessel was sent to intercept its voyage, and a courier was despatched by land to stop the ship at the Sound, but both were too late. Besides many valuable books, the collections contained 19,000 plants, more than 3,000 insects, 1,500 shells, 2,500 minerals, a large number of corals, 150 fishes, and a few birds.

In 1788, Dr. (afterwards Sir) James Edward Smith founded the Linnean Society, which for some years met at his house in London. At his death, in 1828, much surprise was felt that the Linnean collections were not bequeathed to the Society but were offered to it for £5,000. They were bought for 3,000 guineas, and have since been in the keeping of the Society. A full account of their history will be found in the *Proceedings* of the Society, 1887-88.

Memorials of Linnæus

PLANTS FROM LINNÆUS'S HERBARIUM

Species of *Carduus* (Thistle) illustrating Linnæus's method of conserving plants, which he thus describes. "Each species I have glued with isinglass on half a sheet of paper, and all the half-sheets that belong to one genus I have put up in a whole sheet of paper, and on the whole sheet I have written the name of the Genus [*Carduus*], and on the half-sheet the name of the Species [*lanceolatus*, *nutans*, &c.]. All these whole sheets, or Genera, I have arranged according to the Orders and Classes." (Extract from Diary.)

The number written before the specific name is the number of the species in Linnæus's *Species Plantarum* (1753), a systematic account of all the species of plants then known, according to which the herbarium is arranged. The letters H U on the last specimen, just beneath the stem, stand for Hortus Upsaliensis, and indicate that the plant was grown in the Upsala Botanic Garden. The pencil notes on the two middle sheets are by Sir James Edward Smith.

SECOND CASE

1 FISHES FROM LINNÆUS'S COLLECTION. These consist of skins pasted upon paper. The specimens shown are Eel, Loach, Trout, Crucian Carp, Pike, Nase, Chub, Bream and Perch.

2 ARTIFICIAL PEARLS FROM LINNÆUS'S COLLECTION. Linnæus experimented on the formation of pearls artificially in a fresh-water mussel, *Unio margaritifer*, a specimen of which is shown, together with some of the pearls produced. Linnæus's method was to make a very small hole in the shell and insert a little round fragment of limestone fixed on the end of a fine silver wire; the fragment formed a nucleus which was slowly covered by lamellæ of calcareous matter deposited by the mollusc and thus formed the pearl. The pearls produced were examined by the Crown Jeweller and declared to be in every way as good as those formed naturally, and a "Secret Com-

Memorials of Linnæus

mittee" of the State Council of Sweden recommended that a reward of 12,000 dollars silver money should be given to Linnæus. It does not appear that Linnæus received this money, but the date of the award, 1761, coincides with the year in which he was ennobled. Details of this episode will be found in Professor Herdman's interesting presidential address to the Linnean Society, May 24, 1905, published in the *Proceedings* of the Society, 1904-5.

3 LINNÆA BOREALIS. The original specimen collected by Linnæus at Lycksele in Lapland, May 29, 1732, and sent in 1735 to his friend Dr. Gronovius (1690-1762) of Leyden, with the suggestion that it should bear his name. Linnæus traced a fanciful analogy between his own early fate and this "little northern plant, long overlooked, depressed, abject, flowering early." A spray of the plant is generally introduced into his portraits. The specimen is from Gronovius's herbarium which was bought by Sir Joseph Banks in 1794,* and is now in the Department of Botany.

Soon after his arrival in Holland in 1735 Linnæus became acquainted with Gronovius, who assisted him in publishing the first edition of the *Systema Naturæ* (exhibited on the other side of the case).

4 SPECIMENS OF COLUMBINE (*Aquilegia vulgaris*) and MARSH MARIGOLD (*Caltha palustris*) from the herbarium of George Clifford containing the plants described in the *Hortus Cliffortianus* (1737). This is exhibited in the third case and contains an account of the plants, both living and dried, in Clifford's collection at Hartecamp. Linnæus was introduced to Clifford, a wealthy banker, whose garden at Hartecamp was one of the richest in the world, by Boerhaave, and was engaged to study and superintend the collection. Through Clifford's generosity

* The Department of Botany of the British Museum, originally known as the Banksian Department, was established in 1827 for the reception of the herbarium of Sir Joseph Banks (1743-1820), the famous traveller, collector and patron of botany. Banks bequeathed his herbarium to his curator Robert Brown, at whose death it was to pass to the British Museum; with Brown's consent it might be removed to the Museum during his lifetime. The removal took place, and Brown became the first Keeper of the new Department.

Memorials of Linnæus

Linnæus was able to visit England in 1736. The herbarium was bought by Sir Joseph Banks in 1791 and passed with the other Banksian collections to the British Museum.

WORKS OF LINNÆUS

1 **SYSTEMA NATURÆ.** Published at Leyden, 1735. One of the earliest works of Linnæus and a very rare book. It consists of eight large sheets in the form of tables, and is a systematic grouping of the three kingdoms of Nature,—Minerals, Plants, Animals. Linnæus's division of plants into twenty-four Classes, determined mainly by the number or some other obvious character of the stamens, is known as the Sexual System.

PLATE ILLUSTRATING THE SEXUAL SYSTEM, by Georg Dionysius Ehret (1708–1770), Leyden, 1736. The coloured drawing shown is the original of a plate illustrating the Classes of the Sexual System, which was published separately by Ehret and afterwards reproduced by Linnæus in the *Genera Plantarum* (1737). Ehret became acquainted with Linnæus at Clifford's house; some of the plates in the *Hortus Cliffortianus* are from his drawings.

2 **GENERA PLANTARUM.** Published at Leyden, 1737. A definition and description of all the genera of plants then known.

3 **SPECIES PLANTARUM.** Published at Stockholm, 1753. A definition and description of all the species of plants then known, and the starting-point of modern botanical nomenclature.

Perhaps the most important service rendered to science by Linnæus was the establishment of a binary system of nomenclature in which every species of plant and animal is designated by two words, e.g., *Rosa canina*—the first, *Rosa*, the name of the genus to which it belongs, and the second, *canina*, the specific or trivial name which distinguishes it from other species of the genus.

The volume is from Linnæus's library and contains notes in his hand.

Memorials of Linnæus

4 FLORA LAPPONICA. Published at Amsterdam, 1737. Linnæus's first Flora, based on his collections in Lapland in 1732 and written while staying with George Clifford at Hartecamp. Sir James Smith in his account of Linnæus (in Rees's Cyclopædia) describes it as "one of the happiest literary compositions of its author . . . redundant in observation and reflection on every subject which could be interwoven with its professed object, conveyed in the most engaging style."

5 FAUNA SUECICA. Published at Leyden, 1746. A systematic account of the animals of Sweden. From Linnæus's own library with notes in his hand.

Soon after the publication of this work Linnæus received the title of Archiater from the King of Sweden.

6 ORBIS ERUDITI JUDICIUM DE CAROLI LINNÆI. Published at Stockholm, 1741. A defence of himself in reply to an attack by J. G. Wallerius entitled *Decades binæ Thesium Medicarum* (Upsala, 1741) (also exhibited). Includes a list of the important events of his life and of his works, and testimonials from eminent men of science.

7 THE DISSERTATION (on the cause of intermittent fevers) submitted by Linnæus for his degree of M.D. which he obtained at the University of Harderwyck in Holland, June 23, 1735. Intermittent fevers are supposed to be owing to fine particles of clay, taken with the food, and lodged in the terminations of the arterial system, where they cause the symptoms of the disorder.

8 COPY OF THE RARE TRACT by Linnæus on Indigenous Plants capable of being utilized for Food. Published at Stockholm, 1757. This is probably the only copy in England. It is a continuation of a better known Thesis on the same subject published in 1752, and was written in consequence of a failure of crops. Linnæus indicates certain native plants which could be used for making bread and generally for food.

Memorials of Linnæus

THIRD CASE

1 PAUL HERMANN'S HERBARIUM OF CEYLON PLANTS. One of four volumes comprising a herbarium of Ceylon plants collected by Paul Hermann, Professor of Botany at Leyden, in 1670-1677; his *Museum Zeylanicum* (1717) is a catalogue of the herbarium. It was sent in 1745 by Augustus Gunther, an apothecary at Copenhagen, to Linnæus, who based upon it his *Flora Zeylanica*, published at Stockholm in 1747. The large writing is that of Hermann and corresponds with the descriptions in the *Museum Zeylanicum*, which is also exhibited. The small writing in ink is that of Linnæus, and corresponds with the citation in the *Flora Zeylanica* (also shown); his numbers are those of the plants in his book. The herbarium was bought in 1793 by Sir Joseph Banks from Professor Treschow of Copenhagen, and is now in the Department of Botany.

2 PORTRAIT OF DANIEL CHARLES SOLANDER (1736-82). A favourite pupil of Linnæus. He came to England in 1760 and became librarian to Banks, whom he accompanied on Cook's first voyage, 1768-71. In 1763 he became an Assistant in the British Museum, and in 1773 was appointed Keeper of the Natural History Department. The portrait is lent by the Print Department, British Museum.

3 PORTRAIT OF JONAS DRYANDER (1748-1810). Also a pupil of Linnæus; he succeeded Solander as librarian to Banks in 1782.

4 HORTUS CLIFFORTIANUS. Published at Amsterdam, 1737. The copy shown formerly belonged to Sir Joseph Banks.

Memorials of Linnæus

At one end of the first case is shown a picture of a microscope presented by Linnæus to Bernard de Jussieu, August, 1738. After leaving Holland in 1738 Linnæus visited Paris, where he became acquainted with Bernard de Jussieu (1699–1776), Demonstrator of Botany at the Royal Garden, and one of the first botanists to work at a natural system of classification of plants. A Latin inscription pasted in the drawer at the base of the microscope states that de Jussieu received it as a perpetual reminder of the social intercourse which he had in August, 1738, with his most delightful comrade Carl Linné. The microscope is now in the Carnegie Museum at New York.

In the wall-case on the left of the bay are shown a number of reprints of Linnæus's works and several publications issued in commemoration of the bicentenary of his birth; also a bronze copy of the bicentenary medal presented to Sir Joseph Hooker, G.C.S.I., &c., by the Royal Swedish Academy of Sciences, 25 May, 1907.

BRITISH MUSEUM (NATURAL HISTORY)

SPECIAL GUIDE No. 4

MEMORIALS OF CHARLES DARWIN

A COLLECTION OF MANUSCRIPTS PORTRAITS
MEDALS BOOKS AND NATURAL HISTORY
SPECIMENS TO COMMEMORATE THE
CENTENARY OF HIS BIRTH AND
THE FIFTIETH ANNIVERSARY
OF THE PUBLICATION OF
"THE ORIGIN OF SPECIES"



LONDON
PRINTED BY ORDER OF THE TRUSTEES
OF THE BRITISH MUSEUM

1909

[PRICE SIXPENCE]



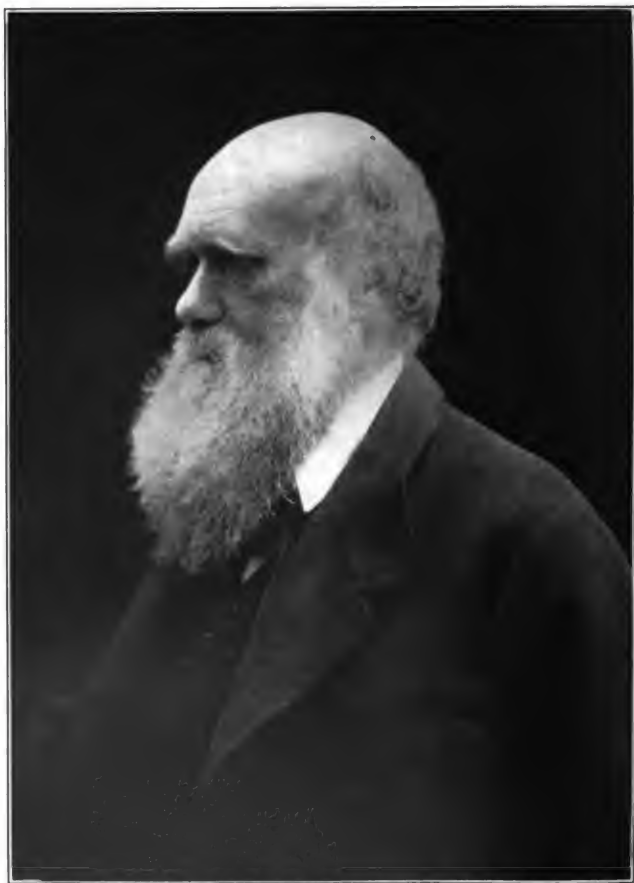
PRESENTED

BY

The Trustees

OF

THE BRITISH MUSEUM.



CHARLES DARWIN.

Photograph by MRS. CAMERON, about 1868.
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BRITISH MUSEUM (NATURAL HISTORY)

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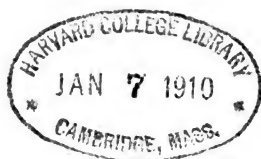


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PREFACE.

BY a coincidence rare in the records of previous celebrations, the year 1909 is at the same time the hundredth anniversary of the birth of a great man and the fiftieth anniversary of the completion of his greatest work. Charles Robert Darwin was born in 1809, and "The Origin of Species" was published in 1859. In recognition of this double motive for signalling the present year, the Trustees directed that an exhibition should be prepared of specimens, autograph letters, books and portraits relating to Darwin.

It is not the part of a Museum to endeavour to decide whether the share ascribed by Darwin to the operation of Natural Selection in the evolution of animals and plants was or was not correctly estimated. Some of the leading Biologists of the present day are in this respect even more Darwinian than Darwin himself, while others attribute less importance than he did to the principle of Natural Selection. But whatever view may be taken of this question, the magnitude of Darwin's influence on contemporary thought can hardly be overestimated, and the desirability of illustrating his teaching can scarcely be questioned.

Without necessarily implying any expression of opinion on controversial matters, it has thus seemed best to illustrate some of Darwin's arguments by means of specimens, using as far as possible the species to which he himself referred in his writings, and in some cases the material which actually passed through his hands. In this part of the Exhibition, the attempt is made to place before the public a few selected examples, to enable those who read Darwin's works to see some of the evidence on which he relied. The "Origin of Species" was naturally chosen in the first instance for illustration: though references to other works are given here and there. Possibly some few of the illustrations may not be well known even to experienced Zoologists and Botanists. It should be understood that the

exhibition makes no claim to be regarded as more than a very small selection, not to be taken as a complete illustration of Darwin's work.

Another set of specimens has a more personal interest, since they were collected by Darwin or are known to have been studied by him. With these may be noticed some of Darwin's apparatus, and a glance will show how simple were the tools with the aid of which his most famous observations were made.

The selection of autograph letters includes some of special interest. Attention may be directed to Nos. 1, 3, 2, in the catalogue, consisting of Professor Henslow's invitation to Darwin to take part in the *Beagle* voyage, of Darwin's summary of his father's objections to the proposal, and of Josiah Wedgwood's reply to those objections. The characteristic and remarkable letter from Huxley (No. 18), written immediately after his first perusal of the "Origin of Species," is one that specially deserves attention.

The exhibition further contains a number of portraits of Darwin, one or two medals founded in his honour, and copies of his printed books. With these are shown a few works, such as those by Haeckel, Weismann and others, which have special reference to Darwin's theories. It will readily be understood that these do not pretend to constitute more than a fraction of the enormous literature that has sprung into existence as the result of the publication of the "Origin of Species."

The greater number of the specimens and books, and a few of the MSS. are the property of the British Museum. For other specimens, as well as for most of the MSS. and portraits and for a few of the books, the Museum is indebted to the owners whose kindness in lending the relics is acknowledged in the pages of this Guide. Special thanks are due to the Council of the Royal College of Surgeons for their loan of the fossils collected by Darwin in South America; and to Mr. William Darwin, Professor Sir George Darwin, K.C.B., F.R.S., Mr. Francis Darwin, F.R.S., Major Leonard Darwin, and Mr. Horace Darwin, F.R.S., for various objects connected with their father's life. To Mr. J. C. Simpson, of Emmanuel College, Cambridge, the Museum is specially indebted for having made arrangements which facilitated the borrowing of some of the objects which were exhibited at Cambridge in June.

In the following catalogue of the exhibits, the source from which the object was obtained is indicated in the case of every specimen or paper borrowed for the occasion. The absence of any such acknowledgment may be taken to imply that the object belongs to the British Museum.

The frontispiece of this Guide is a reduced reproduction of a photograph taken about 1868 by Mrs. J. M. Cameron, Freshwater, Isle of Wight, lent for the purpose by Mr. Francis Darwin, and published by kind permission of Mr. John Murray. The other plate, facing page 7, is a photographic reproduction of the statue of Darwin, by Sir J. E. Boehm, R.A., on the main staircase at the North end of the Central Hall.

The arrangement of the specimens for exhibition, and the preparation of this Guide-book are the work of Dr. W. G. Ridewood.

SIDNEY F. HARMER,

Keeper of Zoology.

BRITISH MUSEUM (NATURAL HISTORY),

LONDON, S.W.

July, 1909.

LIFE OF DARWIN.

CHARLES ROBERT DARWIN was born at Shrewsbury on February 12th, 1809. He was the son of Robert Waring Darwin, a Doctor of Medicine of Shrewsbury, and grandson of Dr. Erasmus Darwin, poet and philosopher, probably best known as the author of "Loves of the Plants." On leaving the Grammar School at Shrewsbury in October, 1825, Darwin went to Edinburgh University to study medicine. His father, however, perceiving that he did not relish the idea of becoming a physician, proposed that he should become a clergyman, and with that intent Darwin went to Cambridge early in 1828, and remained there three years. He left Cambridge to join the *Beagle* as naturalist of the expedition, and was away from England from December, 1831 to October, 1836.

On his return from the *Beagle* voyage Darwin settled in Cambridge, and in March, 1837, took lodgings in Great Marlborough Street, London, where he stayed two years till his marriage in January, 1839. He married his cousin, a grand-daughter of Wedgwood, the famous potter. He had by this time finished the "Journal" of the *Beagle* voyage (republished later as "A Naturalist's Voyage Round the World"), and was preparing his "Geological Observations," which were produced in the form of three books, in 1842, 1844 and 1846 respectively; and he was also engaged in editing the "Zoology of the Voyage of H.M.S. *Beagle*," which appeared in five parts between 1839 and 1843. He lived in Upper Gower Street from January, 1839, to September, 1842, when he moved to Down, in Kent, where he remained for the rest of his life. In October, 1846, he began his study of the Cirripedia, upon which he wrote four volumes (1851-1854).

The idea of selection by nature had been working in his mind since the voyage of the *Beagle*. The succession of the great extinct Edentates of the Pampas of Argentina by the modern Armadillos, and the peculiarities of the fauna of the Galapagos Archipelago, the productions of each island of which differ slightly

from those of the other islands, pointed to species being capable of modification, in a gradual manner. But he admitted to being puzzled by structural features specially adapted to habits and surroundings, such as the modification of the feet and tail-feathers of the woodpecker for climbing trees, and of hooks and plumes of seeds for dispersal. He commenced to accumulate a vast mass of evidence to show the extent to which artificial selection by man has resulted in the production of varieties among domesticated animals and cultivated plants, and in 1838, after reading the "Essay on the Principles of Population," by Thomas Malthus, in which the struggle for existence among human beings is clearly set forth, he conceived the idea that a similar struggle among animals and plants had led to the extinction of those individuals which were least fitted to their environment, and that by differentiation, resulting from the action of different environmental conditions on organisms at first similar, new species had come into existence. In June, 1842, he first committed his ideas on the subject to paper, and this first draft, of thirty-five pages, he rewrote and expanded to 230 pages in 1844.

When it became known in 1858 that Alfred Russel Wallace had independently arrived at somewhat similar conclusions, it was arranged by Lyell and Hooker that Darwin and Wallace should expound their views jointly at a meeting of the Linnean Society. The title of the joint paper was "On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection."

In the following year Darwin produced his "Origin of Species," a book which in his autobiography of 1876 he admits to be the chief work of his life. The first edition (1250 copies) was sold out on the day of its production, November 24th, 1859, and Darwin immediately set to work to revise the book for a second edition, which appeared on January 7th, 1860, and consisted of 3000 copies. The sixth and last edition was published in January, 1872, and of this numerous reprints have been issued.

In 1860 Darwin began arranging his notes for the "Variation of Animals and Plants under Domestication," a work which appeared in 1868. In 1862 he published his book on the "Fertilisation of Orchids," and afterwards his papers, read before the Linnean Society, on dimorphism in *Primula* and trimorphism in *Lythrum*. His paper on "Climbing Plants" in 1865 was reproduced in book form in 1875.

He published the "Descent of Man" in 1871, the "Expression of the Emotions" in the autumn of 1872, "Insectivorous Plants"

in 1875, the "Effects of Cross and Self Fertilisation in the Vegetable Kingdom" in 1876, the "Different Forms of Flowers on Plants of the Same Species" in 1877, the "Power of Movement in Plants" in 1880, and the "Formation of Vegetable Mould through the Action of Worms" in 1881.*

Darwin was awarded the Royal Medal of the Royal Society in 1853, and the Copley Medal in 1864, and the Wollaston Medal of the Geological Society in 1859. He died at the age of 73 on April 19th, 1882, and was buried in Westminster Abbey.

* A complete list of Darwin's books and his contributions to scientific periodicals is to be found at the end of the third volume of the "Life and Letters of Charles Darwin," by his son, Francis Darwin, 1887.

DARWIN EXHIBITION.

LIST OF CASES, IN NUMERICAL ORDER.

The special cases containing the specimens illustrative of Darwin's life and work are indicated by pale green labels. To facilitate the finding of any particular case they are numbered in as consecutive a manner as their positions will permit. It is not recommended, however, that the visitor should proceed from case to case in the numerical sequence; it is intended that the exhibits shall be reviewed in the order in which they are referred to in the descriptive "List of Exhibits" (p. 7 *et seq.*).

Case 1. A large frame on the right-hand side of the Eastern * arch leading to the North Hall, containing Manuscripts of Darwin.

Case 2. The North wall-case of Bay VI,† containing a series of Burrowing Animals, an illustration of "adaptive modification."

Case 3. An upright table-case on the East side of the main staircase, containing Manuscripts and Books by Darwin, or connected with Darwin's life and work.

Case 4. An upright, shallow case set obliquely across the entrance of Bay VI, containing Medals and Portraits of Darwin, and other photographs and sketches of interest in connection with Darwin's life and work.

Case 5. A frame on the North side of the arch of Bay VII, containing a series of feathers of the Peacock illustrating "gradation in ornament." ("Descent of Man." Chap. xiv.)

Case 6. The North wall-case in Bay VII, containing at the left-hand end and on the floor specimens collected by Darwin, or studied by him; and in the remainder of the case specimens illustrating passages in Darwin's books.

* The entrance to the Museum is at the *South* end of the Central Hall, and the main staircase is at the *North* end; the side of the Hall to the right of the visitor on entering is the *East*.

† The Bays or Recesses around the Central Hall are denoted by numerals. On the *East* side, the Bay nearest the Huxley statue is No. X, and that by the side of the main staircase is No. VI.

Case 7. An upright table-case in Bay VII, containing specimens, chiefly Insects, illustrating protective coloration, warning coloration, and mimicry.

Case 8. A small black case containing a microscope, set on a table at the end of Bay VII. In this case are shown specimens of avicularia and vibracula of Polyzoa.

Case 9. The South wall-case in Bay VII, containing a series of specimens illustrating passages in Darwin's books, more particularly the "Origin of Species"; a continuation of the series shown in Case 6.

Case 10. A frame on the South side of the arch of Bay VII, containing a series of feathers of the Argus Pheasant. ("Descent of Man." Chap. xiv.)

Case 11. A black table-case set across the entrance to Bay VIII, containing the fossil remains of extinct Mammals collected by Darwin in South America in 1833.

Case 12. The North wall-case in Bay IX, containing a series of specimens in continuation of those shown in Cases 6 and 9.

Case 13. A horizontal table-case in Bay IX, containing on the one side specimens of Cirripedia or Barnacles studied by Darwin during the years 1846-1854, and described in his monograph on that group of animals; and on the other side specimens of Corals collected by Darwin at Keeling Island in 1836.

Case 14. An upright case near the foot of the staircase, containing a series of Desert Animals, showing the uniform sandy coloration which renders these animals so little conspicuous in their natural surroundings.

Case 15. An upright case containing a series of animals, principally Birds and Mammals, exhibiting albinism.

Case 16. An upright case containing Birds and Mammals exhibiting melanism.

Case 17. An upright case containing typical specimens of the Carrion Crow (*Corvus corone*) and Hooded Crow (*Corvus cornix*), and a map showing the distribution of each species; also examples of Birds exhibiting characters intermediate between those of the two species, obtained from a region where both species occur and interbreed. The same case contains a series of Goldfinches exhibiting characters intermediate between those of the Common Goldfinch (*Carduelis elegans*) and the Himalayan Goldfinch (*Carduelis caniceps*),

obtained from a region where the geographical areas of the two species overlap.

Case 18. An upright case containing in the upper part the wild Rock Pigeon (*Columba livia*), and below examples of the principal breeds of domestic Pigeon, illustrating the great variation which a species may exhibit in a state of domestication by careful selective breeding. ("Animals and Plants under Domestication." Chaps. v and vi.)

Case 19. A table-case near the Owen statue, containing models and specimens illustrating the Fertilisation of Flowers. ("Fertilisation of Orchids," 1862, and "Cross and Self Fertilisation of Flowers," 1876.)

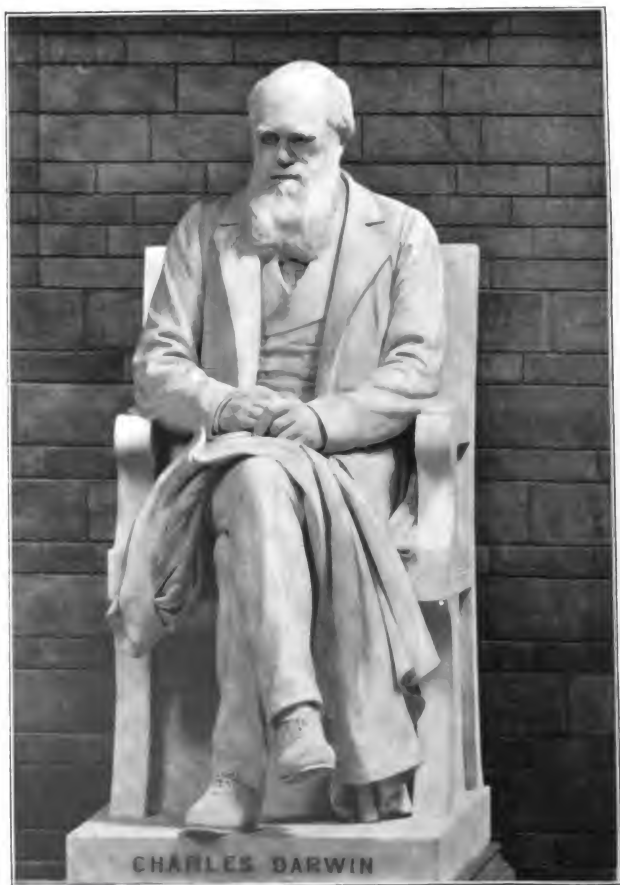
Case 20. A table-case containing models and specimens illustrating the structure of Insectivorous Plants. ("Insectivorous Plants," 1875.)

Case 21. An upright case containing examples of the Red Jungle Fowl of India, and specimens of the principal breeds of domestic Fowl, illustrating the great variation which a species may exhibit in a state of domestication by careful selective breeding. ("Animals and Plants under Domestication." Chap. vii.) The case also contains a series of wild and domestic Canaries.

Case 22. An upright case containing Ruffs and Reeves (*Pavonella pugnax*), showing the remarkable difference in the plumage of the two sexes, and the variability of that of the male, during the breeding season.

Case 23. An upright case containing Drakes and Ducks (*Anas boschas*), showing the remarkable difference in the plumage of the two sexes during the breeding season.

Cases 24 and 25. Upright cases containing Mammals and Birds from Norway, illustrating the adaptation of the colour of the coat to that of the natural surroundings, by virtue of which the animals are rendered less conspicuous to their enemies, or to their prey. In Case 24 the animals are shown as they appear in summer; in Case 25 as they appear in winter.



Statue by SIR JOSEPH BOEHM, R.A., 1885.
Photograph by MR. H. G. HERRING.

LIST OF EXHIBITS.

STATUE.

At the top of the first flight of stairs at the North* end of the Central Hall, a sitting statue of Darwin executed by Sir J. E. Boehm, R.A., as part of the "Darwin Memorial" raised by public subscription. It was unveiled on June 9th, 1885, when an address was delivered on behalf of the Memorial Committee by the late Professor Huxley, Pres. R.S., to which His Majesty the King (then Prince of Wales), representing the Trustees, replied. A photographic reproduction of the statue faces this page.

MANUSCRIPTS.

In Case 1, a large frame on the right-hand side of the Eastern arch leading from the Central Hall to the North Hall :—

1. A letter, dated August 24th, 1831, from Henslow to Darwin, inviting him to travel as naturalist on the *Beagle*. Darwin was eager to accept, but his father objected, in the terms set forth in MS. No. 3 here shown. The objections were submitted to Darwin's uncle, Josiah Wedgwood, whose reply is here shown (No. 2). Lent by Francis Darwin, Esq., F.R.S.

2. A letter from Josiah Wedgwood (second son of the distinguished potter) to Darwin's father, which decided the latter to allow his son to go on the *Beagle* expedition. Dated August 31st, 1831. Lent by Francis Darwin, Esq., F.R.S.

3. A manuscript by Charles Darwin detailing his father's objections to his going on the *Beagle* voyage. Lent by Francis Darwin, Esq., F.R.S. This paper was submitted to Josiah Wedgwood, when his advice was solicited, and it is referred to in Wedgwood's reply here shown (No. 2). The objections are as follows :—

- " 1. Disreputable to my character as a Clergyman hereafter.
- " 2. A wild scheme.
- " 3. That they must have offered to many others before me the place of Naturalist.
- " 4. And from its not being accepted there must be some serious objection to the vessel or expedition.

* See footnote, p. 4.

- "5. That I should never settle down to a steady life hereafter.
- "6. That my accommodations would be most uncomfortable.
- "7. That you should consider it as again changing my profession.
- "8. That it would be a useless undertaking."

4. Four pages of zoological notes on *Aplysia*, *Planaria*, and *Cleodora*, made by Darwin during the voyage of the *Beagle*. They are dated February, 1832. Lent by Francis Darwin, Esq., F.R.S.

5. A list of the officers and men of the *Beagle*, dated October, 1836, *i.e.*, on the completion of the voyage. Darwin's name occurs at the top of the left-hand column. Lent by Francis Darwin, Esq., F.R.S.

6. A letter from Darwin to Owen, dated Thursday 28th, 36, Gt. Marlboro' St., referring to the return of the proof-sheets of Owen's paper on *Toxodon*, which were submitted to Darwin for criticism. The date is probably 1837.

7. A letter from Darwin to George R. Gray, of the British Museum, thanking him for a copy of his book on the "Genera of Birds," and expressing a hope that he would now be free to complete the volume of the *Beagle* Birds left unfinished by John Gould. The date of the letter is probably 1840.

8. A letter from Darwin to Owen referring to a weathered Elephant's tooth and a tusk from Peru. Judging from the address (12, Upper Gower Street) the date of the letter is between 1839 and 1842.

9. A letter from Darwin to Daniel Sharp dealing with foliation, cleavage, stratification, volcanic rocks, and other geological matters. The letter bears the postmark November 2nd, 1846.

10. A hitherto unpublished letter bearing the post-mark August 2nd, 1843, written by Darwin to G. R. Waterhouse (afterwards of the British Museum), and expressing his views as to what should be aimed at in classifying animals and plants. He writes: "All rules for a natural classification are futile until you can clearly explain what you are aiming at. Until that is done I must protest against sameness of country (as with the Monotremata) being used. . . . I believe . . . that if every organism which ever had lived or does live were collected together (which is impossible, as only a few can have been preserved in a fossil state), a perfect series would be presented, linking all, say the Mammals, into one great, quite indivisible group." Lent by C. O. Waterhouse, Esq.

11. A letter from Darwin to Owen, saying that Captain Sullivan, R.N., had arrived in London with six casks of fossil bones from the southern part of Patagonia, and expressing a wish to examine the bones with Owen, when they had been unpacked at the Royal College of Surgeons Museum. Date probably between 1840 and 1850.

12. A letter from Darwin to Owen, dated "Nov. 25th, Down, Farnborough, Kent," asking for the loan of some Barnacles from the College of Surgeons Museum. Date between 1846 and 1851.

13. A hitherto unpublished letter, bearing the post-mark July 27th, 1843, written by Darwin to G. R. Waterhouse (afterwards of the British Museum). Darwin writes, in reference to a discussion on classification:—"It has long appeared to me that the root of the difficulty in settling such questions as yours—whether number of species, etc., etc., should enter as an element in settling the value or existence of a group—lies in our ignorance of what we are searching after in our natural classification. . . . According to my opinion . . . classification consists in grouping beings according to their . . . descent from common stocks. . . . There is one caution . . . the great doubt whether the groups which are now small may not have been at some former time abundant, and you will admit fossil and recent beings all come into one system. . . . Perhaps if the Goatsucker and Woodpecker were varied into very many genera, and very many species of each, they would be looked on as orders equal to the Hawks, etc." Lent by C. O. Waterhouse, Esq.

14. The first page of Darwin's 1844 sketch of his theory on the origin of species. The first clear conception of the theory occurred to Darwin at the end of 1838, or the beginning of 1839, but he did not set it out in writing till June, 1842. The 1842 draft consisted of 35 pages, and this was rewritten and expanded to 230 pages in the summer of 1844. The manuscript shown is the first page of the 1844 draft. Lent by Francis Darwin, Esq., F.R.S.

15. A letter from Darwin to Owen, asking for a specimen of *Balanus glacialis* from the College of Surgeons Museum. The left-hand half of the letter is a personal one to Owen, the right-hand half is a formal application which Owen might lay before the Council of the College if the sanction of that body were necessary. The date is probably 1852 or 1853.

16. A letter from Darwin to S. P. Woodward, of the British Museum, best known as the author of the "Manual of the Mollusca."

In this letter Darwin expresses his inability to accept the view (Carpenter's, 1844) that the Hippuritidæ are in any way a connecting link between the Oysters and the Barnacles. The date is probably 1854. Lent by B. B. Woodward, Esq.

17. A letter from Darwin to S. P. Woodward, in which he discusses the relative antiquity of volcanoes, and expresses his disagreement with Von Buch's "elevation-crater-theory." The date is about 1860. Lent by B. B. Woodward, Esq.

18. A letter from Huxley to Darwin, dated November 23rd, 1859, in which he states that he has finished reading the "Origin of Species," and expresses the pleasure that the new views have given him. He advises Darwin not to be annoyed by the abuse which is doubtless in store for him, and assures him that he can rely upon the support of his friends. The letter is published in "Life and Letters of Charles Darwin," by F. Darwin, Vol. ii, pp. 231-2. Lent by Francis Darwin, Esq., F.R.S.

19. A letter from Darwin to Owen, dated December 13th, 1859, referring to the "Origin of Species," which had appeared during the preceding month. The letter is published in "The Life of Richard Owen," by R. Owen, 1894, Vol. ii, pp. 90-91.

20. A letter from Darwin to G. R. Waterhouse, of the British Museum, concerning "the eldest son of Sir J. Lubbock," the present Lord Avebury, whom he wished to propose for membership of the Entomological Society. Date, 1850.

21. A letter written by Darwin in 1854 or 1855 to William Harris, of Charing, Kent, from whom he had borrowed some Cirripedes to study when writing his monograph on that group of animals. Lent by C. D. Sherborn, Esq.

22. A long letter from Darwin to a correspondent whose name does not appear on the letter, and who was evidently opposed to the views expressed in the "Origin of Species." Darwin writes that as the undulatory theory of light is based on analogy with the passage of sound waves through air, so he defends his theory of natural selection by analogy with artificial selection. In the latter part of the letter he states that he did not discuss "alternation of generations," because he looked upon the non-sexual reproduction as a process of gemination during a larval stage, and that the life-history as a whole does not differ essentially from one in which there is no alternation. The date of the letter is probably 1861.

23. A letter from Darwin to Owen, dated "Saturday evening,

Down, Farnborough, Kent," referring to negotiations for the purchase of a skeleton of the Sabre-toothed Tiger, *Machairodus*, offered by Señor F. Muniz, and to a translation into English of a Spanish paper on these remains.

24. A letter from Darwin to Samuel Butler thanking him for a copy of a work of his, probably either "Erewhon" (1872) or "The Fair Haven" (1873), both of which were published under the initials "S. B." Darwin states that he would not have suspected Butler as the author of the book. The date of the letter is probably 1872 or 1873.

MANUSCRIPTS (*continued*), BOOKS,* Etc.

In Case 3, a large table-case standing on the Eastern side of the main staircase :—

25. An early note-book of Darwin's containing observations made when he was at Edinburgh in March 1827. On the right-hand page shown he describes his discovery of the young of the Skate-leech, *Pontobdella muricata*. Lent by Francis Darwin, Esq., F.R.S.

26. Darwin's pocket-book, containing notes made in September, 1834, while at Santiago, during the voyage of the *Beagle*. Most of the notes are geological, but some refer to the natural history of the country. Lent by Francis Darwin, Esq., F.R.S.

27. Darwin's pocket-book, containing notes on the geological structure of the Coquimbo valley made after the arrival of the *Beagle* at Valparaiso in July, 1834. The notes are in pencil throughout, and each page is scored across, presumably to denote that a copy had been made. Lent by Francis Darwin, Esq., F.R.S.

28. Letters written by Darwin during the voyage of the *Beagle* to Professor Henslow, who read them at a meeting of the Cambridge Philosophical Society in November, 1835, and had them printed for distribution among the members of the Society.

29. Twenty-four pages of notes of Insects caught during the voyage of the *Beagle*. The corrections and additions are in Darwin's handwriting. The capture of live beetles in the sea at a distance of seventeen miles from land, here recorded, is published in the "Naturalist's Voyage round the World," p. 159 of the 1882 edition.

* Only a selected series of Darwin's books and scientific papers is here shown; a complete list of his writings is to be found at the end of Vol. iii of the "Life and Letters of Charles Darwin," by F. Darwin, 1887. A large proportion of the books in Case 3 are books on Darwinism, and other writings inspired by Darwin's work.

30. Microscope used by Darwin on the *Beagle*. Lent by Sir George H. Darwin, K.C.B., F.R.S.

31. Microscope used by Darwin. Lent by Sir George H. Darwin, K.C.B., F.R.S.

32. Simple microscope used by Darwin on the *Beagle*. Lent by Sir George H. Darwin, K.C.B., F.R.S.

33. (At the top of the case). Dissecting microscope used by Darwin. Lent by Francis Darwin, Esq., F.R.S.

34. A volume of notes on Reptiles, etc., made on the *Beagle* expedition, those on the left-hand page shown being in Darwin's handwriting. Date, September, 1835; locality, Galapagos Islands. The first note on the page has reference to the Sea Iguana, *Amblyrhynchus cristatus*, a lizard of which Darwin gives a figure in the "Naturalist's Voyage round the World," p. 385. (A stuffed specimen of the lizard is shown in Case 12.) Of further interest is the pencil note on the right-hand page allotting specimen 1315, another *Amblyrhynchus*, for dissection by Mr. Owen.

35. Darwin's "Naturalist's Voyage round the World" or "Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H.M.S. *Beagle* round the World, under the command of Captain Fitzroy, R.N.," 1882. (The original appeared in 1839 in Vol. iii of the "Narrative of the Surveying Voyages of H.M.S. *Adventure* and *Beagle*." It was issued separately as "Journal of Researches, etc.," and a second edition appeared in 1845, and was re-issued in 1860 with a postscript.) The book is opened at pp. 384-5, showing a figure of the Sea Iguana, *Amblyrhynchus cristatus*, mentioned in the MS. above.

36. "Zoology of the Voyage of H.M.S. *Beagle*," edited and superintended by Charles Darwin:

Part I. Fossil Mammalia, by Richard Owen, 1840.

Part II. Mammalia, by G. R. Waterhouse, 1839.

Part III. Birds, by John Gould (and G. R. Gray), 1841.

Part IV. Fish, by the Rev. Leonard Jenyns, 1842.

Part V. Reptiles, by Thomas Bell, 1843.

37. Darwin's "Structure and Distribution of Coral Reefs"; being Part I of the Geology of the Voyage of the *Beagle*. London, 1842. (Republished with Parts II and III in 1851; Second Edition, 1874; Third Edition, 1889.)

38. Darwin's "Geological Observations on the Volcanic Islands

visited during the Voyage of H.M.S. *Beagle*"; being Part II of the Geology of the Voyage of the *Beagle*. London, 1844. (Republished with Parts I and III in 1851; Second Edition, with Part III, 1876.)

39. Darwin's "Geological Observations on South America"; being Part III of the Geology of the Voyage of the *Beagle*. London, 1846. (Republished with Parts I and II in 1851. Second Edition, with Part II, in 1876.) The three fossils figured in the left top corner of the plate shown are exhibited in Case 6.

40. Several pages in Darwin's handwriting of an abstract of Pallas's "Mémoire sur la variation des animaux" (Acta Acad. Sci. Imp. Petropol., 1780). It is interesting as showing the kind of abstracts Darwin made of the books that he read. Lent by Francis Darwin, Esq., F.R.S.

41. Pallas's paper, "Mémoire sur la variation des animaux" (Acta Acad. Sci. Imp. Petropol., 1780), opened at pages 84 and 85 for comparison with the notes made by Darwin and shown in the manuscript above.

42. A note-book of Darwin's, dealing chiefly with expression. It bears the date 1838, and the address 36, Great Marlborough Street, and contains numerous references to information supplied by his father in the course of conversation. Lent by Francis Darwin, Esq., F.R.S.

43. A copy of questions on cross-breeding drawn up by Darwin for circulation among farmers and cattle-breeders. The questions are twenty-one in number, and are printed with a wide margin for replies. The copy is not dated, but since it is addressed from 12, Upper Gower Street, the date of issue is probably about 1840.

44. Darwin's "Monograph of the Sub-class Cirripedia, with Figures of all the Species." The Lepadidæ, or Pedunculated Cirripedes. London, 1851. (Ray Society.)

45. Darwin's "Monograph of the Sub-class Cirripedia, with Figures of all the Species." The Balanidæ, or Sessile Cirripedes, the Verrucidæ, etc. London, 1854. (Ray Society.)

46. Darwin's "Monograph of the Fossil Lepadidæ, or, Pedunculated Cirripedes of Great Britain." London, 1851. (Palæontographical Society.) "A Monograph of the Fossil Balanidæ and Verrucidæ of Great Britain." London, 1854. (Palæontographical Society.)

47. A letter from Darwin to Owen, dated July 17th, 1854, in reply to a letter from Owen complimenting him on his monograph on the Cirripedia. The letter is published in "The Life of Richard Owen," by R. Owen, 1894, Vol. i, pp. 407-8.

48. "The Life of Richard Owen," by R. Owen, Vol. i, p. 408, showing the letter from Darwin to Owen, of which the original is shown above.

49. Two selected pages of Darwin's copy of his letter to Prof. Asa Gray, dated September 5th, 1857, a letter which constituted part of the paper "On the Tendency of Species to form Varieties, and on the Perpetuation of Varieties and Species by Natural Means of Selection," which was communicated to the Linnean Society by Darwin and Wallace jointly on July 1st, 1858. The letter was published in the *Journal of the Linnean Society, Zoology*, Vol. iii, No. 9, 1858 [1859], pp. 50-53 (see copy here shown), and was republished in "The Darwin-Wallace Celebration" volume of the Linnean Society, 1908, pp. 95-98.

50. *Journal of the Linnean Society, Zoology*, Vol. iii, London, 1859. The copy is opened at pp. 50 and 51, showing the letter from Darwin to Asa Gray, of which the original MS. is here exhibited.

51. "The Foundations of the Origin of Species," being Darwin's 1842 preliminary sketch of the Origin of Species, edited by Francis Darwin, F.R.S., and printed by the Cambridge University Press, 1909. Copies of this book were presented by the Syndics of the University Press to the delegates and other guests at the Cambridge Darwin Commemoration, June 23rd, 1909.

52. Darwin's "On the Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life," London, 1859. (Second Edition, 1860; Third, 1861; Fourth, 1866; Fifth, 1869; Sixth, 1872.) The copy shown is of the first edition. Lent by J. C. Simpson, Esq.

53. A paper by Dr. W. C. Wells, entitled, "An Account of a Female of the White Race of Mankind, part of whose Skin resembles that of a Negro," a paper in which he recognises the principle of natural selection in the case of the different races of man, and compares it with the improvement of the varieties of domestic animals by selective breeding. The paper was read before the Royal Society in 1813, but was not published by that body; it appeared as part of Dr. Wells's book on "Single Vision, Dew, Letter to Lord

Kenyon, etc.," in 1818 (the book here shown). The paper was apparently unknown to Darwin at the time that he wrote the "Origin of Species." In the "Historical Sketch" at the beginning of the sixth edition of that work he gives a lengthy quotation from it, including the passage here marked.

54. Note B of the Appendix of Patrick Matthew's book on "Naval Timber and Arboriculture," 1831, in which a reference to Nature's method of elimination of the least fit is expressed in the words—"those individuals who possess not the requisite strength, swiftness, hardihood, or cunning falling prematurely without reproducing . . . their place being occupied by the more perfect of their own kind . . ." (p. 365). A similar statement occurs on p. 384, in a section of the Appendix devoted to the adaptation of living things to their environment.

Although Matthew's book was published in 1831, Darwin did not see it till April, 1860, after the appearance of the second edition of the "Origin of Species," when Matthew republished his views in the *Gardener's Chronicle*. Darwin at once wrote to the *Gardener's Chronicle* a letter, in which occur the words, "I freely acknowledge that Mr. Matthew has anticipated by many years the explanation which I have offered of the origin of species, under the name of natural selection."

55. A copy of the first edition of the "Vestiges of the Natural History of Creation," published anonymously in 1844, and attributed to various writers, but subsequently known to be the work of Robert Chambers. The author writes (p. 222): "The idea which I form of the progress of organic life upon the globe . . . is that the simplest and most primitive type, under a law to which that of like-production is subordinate, gave birth to the type next above it, that this again produced the next higher, and so on to the very highest, the stages of advance being in all cases very small—namely, from one species only to another; so that the phenomenon has always been of a simple and modest character." Since the book appeared after Darwin had rewritten and expanded the first draft of his views upon the origin of species, it cannot have influenced him much, but Darwin frankly admits, nevertheless, in the "Historical Sketch" in the sixth edition of the "Origin of Species," that the writer of the book "argues with much force on general grounds that species are not immutable productions."

56. A letter written by Darwin to Owen, giving the reference to the page in Hearn's "Travels" in which mention is made of

North American bears swimming in water and swallowing water-insects. Owen criticised Darwin for suggesting that this habit of the bear might in course of time lead to the evolution of a purely aquatic animal "like a whale" (see p. 25 of Owen's *Edinburgh Review* article here shown).

The letter also refers to a copy of Hunter's "Essays and Observations" which he was expecting to receive from Owen. The printed slip giving the address to which Darwin wished the book sent is interesting as showing the methodical habits of the writer.

Judging from the date of Owen's criticism and the date of the publication of Hunter's book, the letter was written in 1860.

57. Proof-sheets of the hostile "Edinburgh Review" article on the "Origin of Species," April 1860, found among the papers of Sir Richard Owen after his death. The article was not signed, but it was generally known to have been written by Owen.

58. Darwin's "On the Various Contrivances by which British and Foreign Orchids are fertilised by Insects, and on the Good Effect of Intercrossing," London, 1862. (Second Edition, 1877.) Lent by Dr. F. Ducane Godman, F.R.S.

59. "Für Darwin," by Fritz Müller, Leipzig, 1864. (A translation by W. S. Dallas was published in London, 1869, entitled "Facts and Arguments for Darwin."). The book deals mainly with Crustacea, and comprises a number of facts which support Darwin's theory of natural selection.

60. "The Darwinian Theory of the Transmutation of Species," examined by a Graduate of the University of Cambridge, London, 1867.

61. Darwin's "Variation of Animals and Plants under Domestication," 2 Vols., London, 1868. (Second Edition, 1875.)

62. "Natürliche Schöpfungsgeschichte," by Ernst Haeckel, Berlin, 1868. (A translation by Miss L. D. Schmitz was published in London in 1875 under the title, "The History of Creation.")

63. "Note alla Teoria Darwiniana," by Achille Quadri, Bologna, 1869.

64. Darwin's "Descent of Man, and Selection in Relation to Sex," 2 Vols., London, 1871. (Second Edition, in one volume, 1874.)

65. "Charles Darwin et ses précurseurs français," Etude sur le Transformisme, by A. de Quatrefages, Paris, 1870.

66. "Studien zur Descendenz-Theorie," by August Weismann, Leipzig, 1875-6. (A translation by R. Meldola was published in London in 1882 under the title "Studies in the Theory of Descent.")

67. A page of Darwin's manuscript of the "Expression of the Emotions," Chapter vi. It has reference to the shedding of tears and it shows the considerable amount of alteration to which the author subjected his original draft before he was satisfied with it. The date is probably about 1871. The copy of the "Expression of the Emotions" which is shown by the side of the manuscript is opened at the page where the particular passage occurs. Lent by Francis Darwin, Esq., F.R.S.

68. Darwin's "Expression of the Emotions in Man and Animals." London, 1872. (Second Edition, 1873.) The copy is opened at pp. 168-169, and the passage of which Darwin's manuscript is shown is marked in the margin.

69. A copy of the First Edition of the "Expression of the Emotions in Man and Animals," 1872, open to show Plate 1, with six figures of crying children. Lent by Dr. F. Ducane Godman, F.R.S.

70. "Le Darwinisme," by Emile Ferrière, Paris, 1872.

71. "Der Darwinismus und die Naturforschung Newtons und Cuviers," by Albert Wigand, Brunswick, 1874-1877.

72. Darwin's "Movements and Habits of Climbing Plants." London, 1875. (Second Edition, 1876; originally published in the Journal of the Linnean Society, Botany, ix, 1865.)

73. Darwin's "Effects of Cross and Self Fertilisation in the Vegetable Kingdom," London, 1876. (Second Edition, 1878.)

74. Darwin's "Insectivorous Plants." London, 1875. (Second Edition, 1875.)

75. Darwin's "Different Forms of Flowers on Plants of the same Species," London, 1877. (Second Edition, 1880.)

76. "The Power of Movement in Plants," by Charles Darwin, assisted by Francis Darwin, London, 1880.

77. Darwin's "Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits," London, 1881. (Second Edition, 1883.) Lent by J. C. Simpson, Esq.

78. "The Life and Letters of Charles Darwin," including an Autobiographical Chapter, by Francis Darwin, 3 Vols., London, 1887.

79. "Darwinism," an Exposition of the Theory of Natural Selection with some of its Applications, by Alfred Russel Wallace, London, 1889.

80. "From the Greeks to Darwin," by H. F. Osborn, New York, 1894 (Columbia University Series). Presented by Messrs. Macmillan & Co.

81. "Darwin and after Darwin," an Exposition of the Darwinian Theory and a Discussion of post-Darwinian Questions, by G. J. Romanes, 3 Vols., London, 1892, 1895 and 1897.

82. "More Letters of Charles Darwin," by F. Darwin and A. C. Seward, 2 Vols., London, 1903. Lent by Mr. John Murray.

83. "Essays on Evolution, 1889-1907," by E. B. Poulton, 1908. Lent by the Oxford University Press.

84. "The Darwin-Wallace Celebration," an account of the celebration held by the Linnean Society of London on July 1st, 1908, this being the fiftieth anniversary of the reading of the joint paper by Darwin and Wallace on July 1st, 1858. The joint paper is republished in this volume, and the speeches made by the seven medallists are recorded. Lent by Dr. S. F. Harmer, F.R.S.

85. "Catalogue of the Library of Charles Darwin, now in the Botany School, Cambridge," compiled by H. W. Rutherford, 1908.

86. "Darwin and Modern Science"; twenty-nine essays in commemoration of the centenary of the birth of Charles Darwin and of the fiftieth anniversary of the publication of the "Origin of Species"; edited by Prof. A. C. Seward, M.A., F.R.S.; Cambridge University Press, 1909.

87. Order of the Proceedings at the Darwin Celebration held at Cambridge, June 22-24, 1909; with a sketch of Darwin's life, and eleven plates. Presented by the Syndics of the University Press, Cambridge.

88. "Christ's College Magazine," Vol. xxiii, No. 70, Cambridge, 1909. Darwin Centenary Number. The book is opened at pp. 222-3, and shows a letter from Darwin to Wallace, April 6th, 1859, after the reading of their joint paper before the Linnean Society and before the publication of the "Origin of Species."

PORTRAITS, SKETCHES, MEDALS, ETC.

In Case 4, an upright case at the entrance to Bay VI, the bay or recess opposite Case 3 :—

89. Water-colour sketch of the *Beagle* in Tierra del Fuego, drawn by —. Martens, artist on the *Beagle* expedition. Lent by Sir George H. Darwin, K.C.B., F.R.S.

90. Coloured print of Christ's College from the street, about Darwin's time. From R. Ackermann's "History of Cambridge," 1815 ; drawn by W. Westall, and engraved by Black. Lent by A. E. Shipley, Esq., F.R.S.

91. Coloured print of the Botanic Gardens, Cambridge, about Darwin's time. From R. Ackermann's "History of Cambridge," 1815 ; drawn by W. Westall, and engraved by J. Stadler. Lent by A. E. Shipley, Esq., F.R.S. The Botanic Garden here shown is the old Botanic Garden of the University, on the site of which most of the Museums and Laboratories were built later. The picture shows, in the middle, King's College Chapel (mentioned by Darwin as one of the things that gave him most pleasure in Cambridge), the tower of St. Bene't's Church (on the left), and that of Great St. Mary's, the University Church (on the right).

92. Portraits of seven generations of Darwins. Charles Darwin is the third of the series. To the left are his son George and grandson Charles ; and to the right his father Robert Darwin, doctor of medicine, his grandfather Erasmus Darwin, author of "Loves of the Plants," Robert, the father of Erasmus, and William, the grandfather. Lent by Sir George H. Darwin, K.C.B., F.R.S.

93. Portrait of Darwin as a boy of seven, with his sister ; reproduced from a small pastel drawing made in 1816 by Sharples, now in the possession of Miss Wedgwood of Leith Hill Place. Lent by Horace Darwin, Esq., F.R.S.

94. Portrait of Darwin's father, Robert Waring Darwin, M.D., F.R.S., born 1766, died 1846 ; mezzotint by Thomas Lupton, after the painting by James Pardon, Shrewsbury ; published 1839.

95. A reproduction by Mr. Dew-Smith of a photograph of Darwin by Messrs. Maull and Fox, taken about 1854. The copy shown is from the "Annals of Botany," xiii, 1899 ; similar reproductions have appeared in "More Letters of Charles Darwin," 1903, and "Darwin and Modern Science," edited by A. C. Seward, 1909. A wood engraving of the photograph was published in *Harper's*

Magazine, October, 1884, and in "Life and Letters of Charles Darwin," Vol. i, 1887.

96. An early portrait of Darwin after T. H. Maguire. (Ipswich British Association Series, 1849.) The copy shown is from the *Bookman*, Feb. 1909.

97. Two Replicas of the Linnean Society's Darwin-Wallace Medal struck in 1908 to commemorate the fiftieth anniversary of the reading of the joint paper by Darwin and Wallace, at the Society's meeting on July 1st, 1858. The medal was designed by Frank Bowcher, Esq. Seven of the medals were awarded in 1908, the first recipient being A. R. Wallace. Lent by C. E. Fagan, Esq., and B. B. Woodward, Esq.

98. Electrotype of the original wax model from which the Darwin Medal of the Royal Society is reduced. Presented to the Museum by the late Sir John Evans, P.S.A., Treas. Roy. Soc., Feb. 28th, 1891. The Darwin Medal was first awarded in 1890, and the first medallist was A. R. Wallace. The medal was executed by Allan Wyon, Esq.

99. Darwin's study at Down, shortly after his death; etching by A. H. Haig, 1882. Lent by Horace Darwin, Esq., F.R.S.

100. Darwin's study at Down, Kent; photograph by W. England. Lent by Francis Darwin, Esq., F.R.S.

101. Photograph of the statue of Darwin by Sir J. E. Boehm, R.A. The statue is situated on the main staircase of the Museum, and the photograph is reproduced opposite page 7 of this Guide. Photograph by Mr. H. G. Herring.

102. Photograph of Darwin taken by Mrs. Cameron about 1868. Lent by Francis Darwin, Esq., F.R.S. This is reproduced, by kind permission of Mr. John Murray, as the frontispiece of this Guide.

103. Photograph of Darwin, about 1874, taken by Major Leonard Darwin, R.E., Pres. R.G.S. Lent by Horace Darwin, Esq., F.R.S. This portrait was engraved on wood for the *Century Magazine*, January, 1883, and is reproduced in "Life and Letters of Charles Darwin," Vol. ii, 1887.

104. Wood engraving by G. Kruell, 1889, of a photograph of Darwin by Messrs. Elliott and Fry, 1882. Lent by the Linnean Society of London.

105. Photograph of Darwin, enlarged from a negative taken by O. J. Rejlander about 1870.

106. A steel engraving by C. H. Jeens of a photograph of

Darwin by O. J. Rejlander in 1870 (?) ; published in *Nature*, June 4th, 1874. Presented by Messrs. Macmillan & Co.

107. Three photographs of Darwin by the London Stereoscopic Company, taken about 1864.

108. Four photographs of Darwin by Messrs. Elliott and Fry, taken in 1882, *i.e.* the year of his death.

109. Photograph of the oil painting of Darwin by W. W. Ouless, R.A., 1875, in the possession of W. E. Darwin, Esq.

110. A half-tone reproduction of P. Rajon's etching of the oil painting of Darwin by W. W. Ouless, R.A., 1875, in the possession of W. E. Darwin, Esq. The copy shown is from the *Bookman*, Feb. 1909.

111. Photograph of the oil painting of Darwin by the Hon. John Collier, R.A., 1881, in the possession of the Linnean Society of London. Lent by the Linnean Society.

112. Photograph of Darwin taken by his son, Major Leonard Darwin, between 1872 and 1878. Lent by Major Leonard Darwin, R.E., Pres. R.G.S.

113. Photograph by W. W. Naunton of the statue of Darwin by H. Montford, situated in front of the Old Shrewsbury School (now a Museum and Library).

114. Photograph of the village of Down, enlarged from a negative by G. W. Smith, Esq. Lent by Horace Darwin, Esq., F.R.S.

115. Photograph of Darwin's House at Down. Lent by Horace Darwin, Esq., F.R.S.

FOSSIL BONES COLLECTED BY DARWIN.

In Case 11, an upright table-case standing across the Entrance of Bay VIII (the third bay or recess on the Eastern side of the Hall counting from the Huxley statue) :—

Fossil bones collected by Darwin in the latter part of the year 1833 and the beginning of 1834, during the voyage of the *Beagle*. They are from the Pampas Formation (Pleistocene) of the Argentine Republic, and the Pleistocene of Patagonia. Darwin presented the bones to the Royal College of Surgeons Museum on his return, and descriptions of them were published by Owen. They are now exhibited here by the courtesy of the Council of the Royal College of Surgeons.

Notable among these remains are two teeth of an extinct Horse

Equus curvidens, the first fossil teeth of a horse-like animal discovered in the New World ; bones and teeth of Great Ground Sloths of the genera *Megatherium*, *Myodon*, and *Scelidotherium* ; bones of *Maraudenia* ; and skull of *Torodon*, a large extinct Ungulate, of the sub-order Toxodontia. Darwin records how he found this particular skull lying in the yard of a farmhouse near the Sarandis, a tributary of the Rio Negro, where the boys had amused themselves by throwing stones at it, and pulling out the teeth. He purchased it, the first discovered relic of the new sub-order, for eighteenpence. A letter from Darwin to Owen concerning this skull is exhibited in Case 1 (No. 6).

BARNACLES AND CORALS STUDIED BY DARWIN.

In Case 13, a table-case standing in Bay IX (the second bay or recess on the Eastern side of the Hall counting from the Huxley statue) :—

Specimens of Cirripedia or Barnacles in illustration of Darwin's work on that group. Darwin's Monograph on the Cirripedia, published in 1851-1854, is still one of the chief works of reference on this group of animals. The work was largely based on an examination of the Museum collection, which therefore contains the type-specimens or co-types of most of the new species described by Darwin. The specimens exhibited comprise :—

A. Common types of Cirripedia, stalked Barnacles, sessile Barnacles, etc.

B. Specimens and drawings illustrating special discoveries made by Darwin :—*Proteolepas*, a maggot-like Barnacle, of which only one specimen has been discovered, *Cryptophialus*, another extremely peculiar form, and the complemental males of *Scalpellum*. The great majority of Cirripedes are hermaphrodite, having both sexes combined in each individual. Darwin discovered, however, that certain species have minute males, which are attached like parasites to the hermaphrodite individuals, and to these he gave the name of "complemental males." In a few species the separation of the sexes is complete, and the large individuals are purely female.

C. Specimens described or mentioned in Darwin's work, with some notes in his handwriting. Particular attention is called to the series of *Balanus amphitrite*, a series selected by Darwin himself, with a manuscript of his in which he expresses the difficulty which he experienced in defining the limits of the species.

On the other side of the case are shown specimens of Corals,

Millepores and Nullipores collected by Darwin in 1836 on Keeling Island, an atoll in the Indian Ocean, 800 miles S.W. of Batavia. The series shows corals in the fresh state and in various stages of conglomeration to form the body of the atoll; also some water-worn coral pebbles. The explanatory account of the specimens is in Darwin's own handwriting: the writing being in places difficult to decipher, a printed copy of it is also shown. Darwin's observations on coral reefs were published in 1842 as the "First Part of the Geology of the Voyage of the *Beagle*—The Structure and Distribution of Coral Reefs"; and a second edition was published in 1874.

OTHER SPECIMENS COLLECTED BY DARWIN, OR
STUDIED BY HIM, OR OTHERWISE CLOSELY
CONNECTED WITH HIS WORK.

In Case 6, the North wall-case in Bay VII, the third recess on the Eastern side of the Hall counting from the Huxley statue, are shown a few of the specimens, other than Corals and Fossil Mammals, collected by Darwin when on the voyage of the *Beagle*.

(The greater part of the collection of natural history specimens was deposited with the Zoological Society, and a selection of the Birds and Mammals was transferred to the British Museum in 1855. The Fishes were sent to Cambridge, and are now in the University Museum of Zoology. The fossil bones were sent to the Royal College of Surgeons Museum, and are shown here in Case 11, on loan from the College. The fossil Mammal bones were described by R. Owen in Part 1 of the "Zoology of the Voyage of H.M.S. *Beagle*," the recent Mammals by G. R. Waterhouse in Part 2, the Birds by J. Gould (and G. R. Gray) in Part 3, the Fishes by L. Jenyns in Part 4, and the Reptiles by T. Bell in Part 5. The Insects were not described in the *Beagle* reports, but an account of the new species was written by G. R. Waterhouse, and published by the Zoological Society.)

116. A selection of *Beagle* Insects.

117. A small selection of *Beagle* Reptiles and Amphibians. The specimens shown are two species of Lizard, a small Snake, and three tailless Batrachians. Of these last the form known as *Rhinoderma darwini*, first known to science through Darwin's capture of it, is of particular interest from the exceptionally large size of the gular pouches of the male, a pair of pouches in the floor of the mouth which in this species extend far back beneath the skin of the belly,

and within which the eggs undergo their development, the young frogs emerging from the mouth of the parent on the completion of the metamorphosis.

118. A small selection of *Beagle* Birds, namely three Mocking Birds (*Mimus*).

119. A small selection of *Beagle* Mammals, namely three Opossums and two Murid Rodents.

120. The skin of the Fox which Darwin killed with a geological hammer in the island of San Pedro, South Chili, in 1834. This is the fox of which Darwin writes: "two of the officers landed to take a round of angles with the theodolite. A fox (*Canis fulvipes*) . . . was sitting on the rocks. He was so intently absorbed in watching the work of the officers that I was able, by quietly walking up behind, to knock him on the head with my geological hammer." ("Naturalist's Voyage round the World," Ed. 2, p. 280.)

121. Darwin's geological hammer, probably the one with which he killed the fox, here shown. Lent by W. E. Darwin, Esq.

122. (In the upper part of the case.) Darwin's insect net, with scissor handles. Lent by Sir George H. Darwin, K.C.B., F.R.S.

123. Three fossil Cephalopods described and figured in Darwin's "Geological Observations on South America," 1846, plate 5. *Nautilus d'Orbignyanus* and *Baculites vagina* were obtained from the Upper Cretaceous of Chili, and *Ancyloceras simplex* from the Cretaceous of Tierra del Fuego. These specimens were transferred from the Museum of Practical Geology in 1880.

124. (In the upper left-hand corner of the case.) The skull of the Niatu Ox sent to Darwin by Captain Sullivan after the return of the *Beagle*. Lent by the Royal College of Surgeons. The Niatu Cattle of South America show what a great difference in the chances of survival or extinction may be made by a small difference in structure. These cattle, owing to the shortness of the muzzle and the consequent projection of the lower jaw, cannot browse on the twigs and reeds to which other cattle are driven in times of drought, and they perish if not fed by their owners. ("Origin of Species," Chap. vii; "Naturalist's Voyage round the World," Chap. viii, Ed. 2, p. 145.) Another skull (**125**), with the front teeth complete, is shown on the floor of the case.

126. (On the floor of the case.) A Porto Santo Rabbit, a breed of rabbit which in Darwin's opinion had by isolation evolved charac-

ters which distinguished it from the original domestic stock ("Animals and Plants under Domestication," Chap. iv). In 1418 a rabbit on a vessel travelling from Spain to Porto Santo, near Madeira, gave birth to young, which were subsequently turned loose on the island, where, in course of time, they multiplied to such an extent as to become a pest. In 1861 two of the Porto Santo rabbits were brought alive to the Zoological Gardens, and it was noticed that these feral rabbits were, on comparison with English wild rabbits, smaller, more wild, shy and active, more nocturnal, and that they did not exhibit the usual blackish grey fur on the upper surface of the tail and the tips of the ears. Since, further, they refused to mate with English rabbits, it was urged that by isolation the feral rabbits had evolved characters not possessed by the original stock. It is now known, however, that the common rabbit of the countries round the Mediterranean is not the same as the English rabbit, and an error in the argument was introduced by instituting a comparison between the Porto Santo rabbit and the English rabbit, instead of the Spanish rabbit.

127. (On the floor of the case.) A small selection of the Ducks studied by Darwin in the course of his work on Domesticated Animals, and presented by him to the Museum. For Darwin's views on Domestic Ducks see "Animals and Plants under Domestication," Vol. i, pp. 290-302.

128. (On the floor of the case.) A small selection of the Pigeons studied by Darwin in the course of his work on Domesticated Animals. See "Animals and Plants under Domestication," Vol. i, pp. 137-235. The birds here shown represent one-third of the Pigeons presented to the Museum by Darwin in 1867. (A carefully mounted Blue Rock Pigeon and most of the common breeds of Domestic Pigeon are shown in Case 18 in the body of the Hall.)

SPECIMENS ILLUSTRATING DARWIN'S DISCOVERIES,
OR ILLUSTRATING PASSAGES IN HIS PUBLISHED
WRITINGS, MORE PARTICULARLY THE "ORIGIN
OF SPECIES."

(The sequence of the specimens is on the whole based on that of the chapters in the "Origin of Species," but owing to various considerations the rule has not been strictly followed. The sixth edition of the "Origin of Species" was used in the arrangement of

the series, and the references to the chapters given in the labels attached to the specimens refer to that edition. The sixth edition, 1872, is the last edition; copies bearing more recent dates are reprints, differing in pagination, but in no essential respect.)

129. (At the left-hand end of Case 6.) A skin of a Peacock Pheasant, *Polyplectron malaccense*, in which Darwin found the clue to the evolution of the single notched "eye" of the Peacock's tail feather from the paired ocellus such as is found in the tail feathers of *Polyplectron chinquis* (also shown). In the frame marked Case 5, near this specimen, are shown Peacock feathers selected and arranged so as to form a graded series, gradation in characters being, as Darwin pointed out, important evidence in arriving at an explanation of the origin of highly complex structures. In connection with these feathers should be studied those of the wings of the Argus Pheasant in Case 10, on the opposite side of the Bay, showing the rows of "eyes" resembling balls in sockets. At the right-hand end of Case 9 is a photograph (204, lent by the University Museum of Zoology, Cambridge) of the fire-screen made from the feathers of the Argus Pheasant referred to by Darwin in his observations on the evolution of ocelli ("Descent of Man," Ed. 2, p. 441).

130. (In the left half of Case 6.) An Indian Jungle Fowl, *Gallus bankiva*, reputed to be the wild ancestral form of the domestic breeds of Fowl. ("Origin of Species," Chap. i.; "Animals and Plants under Domestication," Chap. vii.) Examples of the principal breeds of Domestic Fowl are shown in Case 21.

131. Blue Rock Pigeon, *Columba livia*, reputed to be the wild ancestral form of all domestic breeds of Pigeon. ("Origin of Species," Chap. i; "Animals and Plants under Domestication," Chaps. v and vi.) Examples of the principal breeds of Domestic Pigeon are shown in Case 18. Attention may here be called to the large series of Domestic Animals of all kinds exhibited in the North Hall.

132. Red Grouse of Britain and Willow Grouse of Norway, cited by Darwin as a case in which difference of opinion existed whether the two birds were of distinct species or were local races of one and the same species. ("Origin of Species," Chap. ii, Doubtful Species.) In connection with the question here raised may conveniently be studied the series of Crows in Case 17. Whether the intermediate forms there exhibited are regarded as having arisen by the interbreeding of two distinct species, or whether the two "species" of Crows are looked upon as dimorphic forms of a single

species, the series is interesting as illustrating the difficulty in defining the limits of a species. The Goldfinches also shown in Case 17 illustrate the same difficulty.

133. A series of thirty-three species of Fresh-water Mussel, *Unio*, from North America. An example of a large or dominant genus which includes a number of very distinct species. ("Origin of Species," Chap. xiv.) The species of the larger genera in each country vary more frequently than the species of the smaller genera. ("Origin of Species," Chap. ii.)

134 (In the upper part of the case.) A series of shells of *Vivipara* (= *Paludina*) of the Pliocene of Slavonia, arranged to show the evolution of ornamented and tuberculated forms in the higher strata from the smooth forms of the lower strata, in accordance with the views of Neumayr and Paul, 1875.

135. A series of shells of a Snail, *Helix picta*, in which the colours and markings of the shell exhibit a wide range of variation within the limits of the species.

136. A series of shells of *Neritina communis*. The colours and markings of the shell exhibit a wide range of variation within the limits of the species, and, as illustrated by the specimens in the bottom row, the same shell may show differences of pattern and colour in its earlier and later parts.

137. A series of shells of *Planorbis multiformis* from the Miocene of Steinheim, showing within the range of the same species a transition from the usual depressed form of shell to the turret form. Similar transitions are known in living species of *Planorbis*. The gradation of the forms of *Planorbis multiformis* in relation with different horizons is referred to in the "Origin of Species," Chap. x.

138. A series of thirty-three shells of *Paludomus loricatus*, from the streams of Ceylon, showing the great variation in size, form, sculpturing, and colouring observable within the limits of the species. Some of the varieties were formerly held to be distinct species, and the names given to the more marked of these have been placed under the examples shown.

139. A series of shells from the Baltic Sea and the North Sea. The Baltic specimens are shown above the corresponding specimens from the North Sea. Darwin suggests that possibly the dwarfing of the shells, admittedly due to the physical conditions of life, might be inherited for at least a few generations, in which case the Baltic

specimens would be called a "variety" of the usual form, such as is found in the North Sea. ("Origin of Species," Chap. ii, Variability.) Presented by the Riksmuseum, Stockholm.

140. Specimens of the Isopod Crustacean *Tanais* or *Leptochelia dubia*. As one of the perplexing differences occurring between individuals of the same species Darwin refers to the statement by Fritz Müller that in *Tanais* there are two forms of males, one with large pincer-claws, and the other with small claws, but with the antennae more abundantly furnished with smelling hairs than in the first kind. ("Origin of Species," Chap. ii.) According to Müller, whose specimens were collected on the coast of Brazil, the two forms of males are not connected by intermediate gradations. Recent investigations on specimens collected at Naples show that intermediate forms do occur between the "high form" *A*, and the "low form" *B*.

141-147. (In the upper part of Case 9.) Seven series of Butterflies selected to illustrate the passages in A. R. Wallace's paper on the Papilionidæ of the Malayan Region (Trans. Linn. Soc., xxv, 1866) referred to by Darwin in Chap. ii of the later editions of the "Origin of Species."

141. Some representative or characteristic species of Butterflies from the Malayan region, belonging to families other than the Papilionidæ.

142. Specimens of *Papilio fuscus* (*P. severus* of Wallace) showing "simple variability." The species occurs in all the islands of the Moluccas and New Guinea, and exhibits in each of them a greater amount of individual difference than often serves to distinguish one species from another.

143. Specimens of *Troides priamus* illustrating "simple variability." In the left upper corner are a male and female from Amboyna, in which island both males and females are constant. Below are one male and two different females from New Ireland, whence a green form of male (not shown here) is also recorded. On the right are two different males and two different females from New Guinea.

144. Polymorphic females in Papilionidæ. In the first column are shown a male and four forms of female of *Papilio polytes*, all from the same locality in Ceylon. The second column shows a male and a "*theseus*" form of female from Sumatra, and below these a male, a "*theseus*" form of female, an intermediate female, and a "*ledebourius*" form of female, all from the Philippine Islands. In

the third column are a male of *Papilio ægeus* and three distinct forms of female (not from the same locality). In the fourth column are examples of seasonal dimorphism in *Araschnia levana*, in which species the second brood differs markedly from the first brood, and intermediate forms occur.

145. Polymorphic Females in Papilionidæ (continued). In the first column are shown a male and two different females of *Papilio memnon* from India; in the second a male and three different females from Java; and in the third column a male and two different females from Borneo.

146. Series of *Papilio agamemnon* illustrating the local races or sub-species occurring in the different islands of the Malay Archipelago. The races are distinguished by differences in size and outline; the differences are tolerably constant in each locality.

147. Series of *Papilio ulysses* illustrating the local races or sub-species occurring in the different islands of the Malay Archipelago. The races are distinguished by differences in the colour-markings, the outline of the wings, and the size of the patches of velvety scales on the fore wings of the males; the differences are constant, each local race being fixed and isolated.

148. (In the upper part of Case 6.) Examples of male and female of the Cock-of-the-Rock, *Rupicola crocea*, a Parrot, *Ectectus cornelia*, the Ruff, *Pavoncella pugnax*, and a Bird of Paradise, *Cicinnurus regius*, showing the differences in the appearance of the two sexes. ("Origin of Species," Chap. iv, Sexual Selection; "Descent of Man," Chap. xiii.) For the aspect of the Ruff at different periods of the year, see Case 22 on the West side of the Hall. Attention may also be directed to the series of Ducks in Case 23.

149. Three male Stag-beetles, with injuries caused by the mandibles of other males in fighting. ("Origin of Species," Chap. iv, Sexual Selection.)

150-156. A series of Birds in illustration of Darwin's observations on the plumage of the young in comparison with that of the adults. ("Descent of Man," Chap. xvi.)

150. House Sparrow, *Passer domesticus*. The adult male is more conspicuous than the adult female (note the dark throat), and the young in its first plumage resembles the female.

151. Bullfinch, *Pyrrhula europæa*. The adult male is more brilliant than the adult female, and the young resembles the female in dullness of coloration, but differs in the absence of black on the top of the head.

152. *Amydrus blythi*, a Starling of Sokotra. The adult male is less conspicuous than the adult female, and the young resembles the male.

153. Starling, *Sturnus vulgaris*. The adult male and female are alike, and the young has a first plumage peculiar to itself.

154. Kingfisher, *Alcedo ispida*. The adult male and female are brilliant and alike, and the young in its first plumage does not differ from the adults.

155. Red Bishop-bird, *Pyromelana oryx*. The adult male has a brilliant summer plumage, and in the winter is dull and resembles the adult female, which is the same in summer and winter; the young resemble the adults in their winter plumage.

156. *Oreopyra leucaspis*, a Humming-bird of Central America. The adult male differs in coloration from the adult female; the young male resembles the adult male, and the young female the adult female.

157. Specimens of the Elephant-fly, *Tabanus internus*, a fly which, by constantly harassing the Elephant and other large mammals, checks undue increase in their numbers. ("Origin of Species," Chap. xi.)

158. Specimens of the Screw-worm Fly, *Chrysomya macellaria*. In Paraguay, where the fly is common, horses, cattle, and dogs are prevented from running wild and flourishing in a feral state by the fly laying its eggs in the navel of the new-born young, with usually fatal results when the maggots hatch out. ("Origin of Species," Chap. iii, Struggle for Existence.) As an illustration of the balance maintained in nature, Darwin suggests that if certain insectivorous birds were to decrease in Paraguay, the parasitic insects which probably attack the navel-frequenting fly would increase, and the fly itself would accordingly decrease. The resulting diminished mortality among the cattle would react on the vegetation, thereby influencing the number of herbivorous insects, and thus of insectivorous birds, "and so onwards in ever-increasing circles of complexity."

159. A copy of the diagram drawn up by Darwin to illustrate his views on the evolution of species. The intervals between the horizontal lines represent large units of time, e.g., a thousand generations; and the letters A to L at the bottom of the diagram stand for the several species of a genus occurring at one time in a country. While some of the species suffer extinction in course of time, as does D before reaching the period represented by the third horizontal line

of the diagram; others, such as F, survive unchanged to the end of the whole period which the diagram is supposed to cover. Other species again, such as A and I, are continually branching out into divergent varieties, most of which become extinct; but others persist, and vary again, until at the end of the whole period (represented by the uppermost horizontal line of the diagram) there are eight different species derived from A, and six from I. For a detailed explanation of the diagram, the visitor is referred to "The Origin of Species," Chap. iv.

160-165. A series of blind animals, mostly cave-dwellers. In instituting a comparison between the blind cave-animals of North America and Europe, Darwin laid stress on the fact that in each case the cave-animals are closely related to the animals of the surrounding country. If the blind animals had been special creations adapted for cave-life generally, one would have expected a close similarity in the organisation and affinities of the animals in the New and Old World caves ("Origin of Species," Chap. v, Effects of Use and Disuse).

160. A Cave-rat, *Neotoma pennsylvanica*, from Virginia, U.S.A. The specimens that live in dark caves are blind, but on being brought gradually into increasing intensity of light they slowly acquire a visual perception of objects.

161. *Ctenomys fuginus*, a burrowing Rodent of South America which is frequently blind. Darwin accounts for the reduction in the efficiency of the eyes as due to disuse, aided perhaps by natural selection, for the eyes in subterranean passages are not only useless as organs of vision, but are disadvantageous, in consequence of their liability to inflammation. Other examples of burrowing animals, many of them partially or totally blind, are shown in Case 2.

162. *Proteus anguinus*, a blind Amphibian of the Caves of Carniola, Austria.

163. Two blind Cave Fishes from the United States, *Typhlichthys roseæ* and *Amblyopsis spelæus*.

164. *Cambarus pellucidus*, a blind Crayfish inhabiting the underground waters of the Mammoth Cave of Kentucky.

165. Several species of *Anophthalmus*, *Bathyscia* and other genera of blind Beetles found exclusively in caves.

166. A series of Dung-beetles, in which the tarsal or terminal joints of the front legs are wanting. In the beetles in the top row

the tarsi are wanting in both sexes ; in the other species exhibited they are absent in the male and very minute in the female. Darwin explains the phenomenon of loss or reduction of the tarsi as due, not to an inheritance of repeated mutilations, but to the effects of long-continued disuse ("Origin of Species," Chap. v, Effects of Use and Disuse). In connection with the disuse of organs in Insects may here be considered the flightless Beetles of Madeira and other islands (225, Case 12), in which the wings have dwindled in size until the power of flight has been lost.

167. A graded series of Lizards of the family Scincidæ showing reduction in the limbs, an illustration of the generalisation that "natural selection will tend in the long run to reduce any part of the organisation as soon as it becomes, through changed habits, superfluous, without by any means causing some other parts to be largely developed to a corresponding degree." ("Origin of Species," Chap. v.)

168. The pelvis and hind limb bones and claws of a large Anaconda Snake, *Boa murina*, an example of vestigial structures. ("Origin of Species," Chap. xiv.)

169. (In the upper part of Case 6.) A Bat, a Flying Squirrel, and a *Galeopithecus*. Darwin, in his reply to the contention that Bats could not have been evolved from a quadruped animal, because the wings in their early stages of evolution would present no advantage to the possessor, and would therefore not be perpetuated by natural selection, instances the Flying Squirrel and *Galeopithecus* as suggesting how, in the early stages of the evolution of Bats, the wings were but a parachute, a fold of skin extending between the fore and hind limbs on each side and between the fingers, and that the power of flapping this membrane was gradually evolved, and eventually the capacity for true flight. ("Origin of Species," Chap. vi.)

170. The fourth vertebra of the neck and the skeleton of the right fore foot of a Giraffe and an Ox, to show the great length of the bones in the former animal. The height of the Giraffe is instanced by Darwin in his reply to Mivart's contention that "natural selection is incompetent to account for the incipient stages of useful structures." Darwin argued that in times of dearth any slight superiority in height would enable a Giraffe to browse upon twigs inaccessible to others of shorter stature, and the taller animals would thus be more likely to survive and to perpetuate the small increment in height. ("Origin of Species," Chap. vii.)

171. (In Case 8, a small black case on a table at the end of Bay VII.) A series of twelve specimens of Polyzoa to illustrate Darwin's observations on the avicularia and vibracula of these animals.

(The focussing of the microscope is effected by rotating the eyepiece ; the slides are brought successively into the field of the microscope by rotating the milled wheel at the right-hand side of the case.)

A. *Fredericella sultana*, a fresh-water species, not uncommon in this country, shown to illustrate the appearance of a Polyzoan in the natural extended position. Each of the individuals of the colony possesses a circlet of tentacles, the cilia of which drive minute food-particles into the mouth, which is surrounded by the tentacles.

In the remaining slides (B—M), the animals are in their retracted condition. The tentacles (not visible in most cases) lie within the cavity of the "zoöcium," the term applied to the units or individual members of the colony. The series illustrates some of the modifications of the avicularia and vibracula, the evolution of which is discussed in Chap. vii of the "Origin of Species." There can be no reasonable doubt that an avicularium is to be regarded as a modified zoöcium, while a vibraculum is an avicularium whose lower, or movable, jaw has been prolonged into a bristle-like structure, the "seta."

B. Part of a colony of a species of *Bugula*, consisting of branches composed of elongated zoöcia arranged in three or four transverse rows. The numerous avicularia are readily recognised by their resemblance to birds' heads. The lower jaw, by means of which the avicularium can grasp a foreign object, corresponds with the lid or operculum of an ordinary zoöcium, with which the avicularium itself corresponds.

This specimen, which, like most of the other slides here shown, has been lent by the University Museum of Zoology, Cambridge, is of special interest in being one of the specimens collected by Darwin during the voyage of the *Beagle*. It may be surmised that Darwin refers to this species, or to one closely allied to it, in Chap. ix of the "Naturalist's Voyage round the World," where he says, "Perhaps the most singular part of their structure is, that when there were more than two rows of cells [zoöcia] on a branch, the central cells were furnished with these appendages [avicularia], of only one-fourth the size of the outside ones," a good illustration of the fact which has often been noted that the observations made during the *Beagle* voyage were the basis of Darwin's later work.

C and D. Fragments of other species of *Bugula*, showing similar avicularia. In D the retracted tentacles and the alimentary canals of the zoœcia are visible.

E. *Beania magellanica*, a species in which the zoœcia are not contiguous, each one bearing a pair of large avicularia near one end.

F. *Bugula reticulata*, an abyssal species in which the avicularia are borne on very long, flexible stalks, and are extremely variable in size in different parts of the same colony.

G-J. Species of *Bicellaria*, a genus allied to *Bugula*. In the species here shown the avicularia are developed to a remarkable extent, and are extremely variable in size.

G. *Bicellaria tuba*, showing the greatly elongated avicularia *in situ* and separated from the branch.

H. *Bicellaria moluccensis*. The muscles by which the lower jaw of the avicularium is closed are readily visible in this preparation. The zoœcia, which have lost their tentacles and internal organs, bear a cylindrical process giving rise to a series of finger-like spines.

J. *Bicellaria pectogemma*. The variation in the size of the avicularia is very striking.

K. *Flustra (Sarsiflustra) abyssicola*, an example of a species with an entirely different type of avicularium. The avicularia are completely in series with the rest of the units of the colony, but may be distinguished by their relatively gigantic operculum, more or less spoon-shaped, and corresponding with the lower jaw of the avicularia of *Bugula* and *Bicellaria*.

L. A species of *Caberea*, showing the thread-like "setæ" of the numerous vibracula. The "elegant little coralline" referred to by Darwin in Chap. ix of the "Naturalist's Voyage round the World" probably belonged to this genus, which is remarkable for the simultaneous movement of the vibracula of the living colony.

M. A species of *Selenaria*, in which the vibracula are larger and the minute teeth borne by the setæ are more obvious than in L.

172. (In the lower part of Case 9.) Specimens of the pelvic and hind limb bones of the Greenland Right Whale, *Balæna mysticetus*, being three selected from a series of eleven described by Sir John Struthers in the Journal of Anatomy and Physiology, 1881. An illustration of the generalisation that rudimentary (vestigial) parts are apt to be highly variable, the variability resulting apparently from their uselessness, natural selection having no power to check deviations in their structure. ("Origin of Species," Chap. v.)

173. (On the sloping back of the case, towards the left-hand end.) Shells of coral-inhabiting Barnacles of the genus *Pyrgoma*, in which the small valves that close the opening of the shell are unusually different in the different species. An illustration of the contention that unusually developed parts are highly variable. ("Origin of Species," Chap. v.) In the rock barnacles the valves of the shell differ extremely little even in distinct genera.

The large specimen on this tablet is figured in Darwin's "Monograph of the Cirripedia," Vol. ii, pl. 13, fig. 1a.

174. A graded series of eight males and one female of the Atlas Beetle, *Chalcosoma atlas*, showing the extreme variability of the secondary sexual characters of the male. The characters in question are the large size of the horns on the head and thorax, the length of the front legs, and the size of the body as a whole. ("Origin of Species," Chap. v; "Descent of Man," Chap. x.)

175. A graded series of nine males and one female of the Indian Stag-beetle, *Odontolabis cuvera*, showing the extreme variability of the secondary sexual characters of the male. The characters in question are the large size of the head and mandibles, and in a lesser degree the length of the front legs, and the size of the body as a whole. ("Origin of Species," Chap. v.)

176. *Mustela vison*, a North American Polecat, instanced by Darwin in reply to an objection that aquatic carnivores could not have been derived from terrestrial forms because the animals could not have existed in the transitional state. Darwin points out that *Mustela vison* has webbed feet and resembles an otter in its fur, short legs and the form of its tail. During the summer it preys on fish, and during the winter it lives like other polecats on mice and similar land animals. ("Origin of Species," Chap. vi.)

177-180. Specimens of *Saurophagus sulphuratus*, *Puffinuria urinatrix*, *Cinclus aquaticus* and *Colaptes campestris*. One of the great difficulties that Darwin had to contend with in the elaboration of his theory was the fact that the known cases of adaptive modifications in their early stages are extremely scarce. The four birds here shown are mentioned by him as instances in which the observed alteration of habits might in course of time result in a gradually improving adaptive modification of certain parts of the body. ("Origin of Species," Chap. vi.)

177. Tyrant Fly-catcher, *Saurophagus sulphuratus*, a bird of South America which at times hovers like a Kestrel, and at other times dashes into water like a Kingfisher.

178. *Puffinuria urinatrix*, a Petrel which in its habits of diving, swimming and flying resembles the Auks and Grebes rather than its own relatives.

179. Water-ouzel, *Cinclus aquaticus*, a bird allied to the Thrushes, yet differing markedly from them in its habit of diving in water.

180. *Colaptes campestris*, a Woodpecker, possessing the long straight beak, the usual arrangement of the toes, two forward and two backward, for grasping boughs of trees, and the stiff tail feathers to support the body against a tree trunk, yet living on the plains of La Plata where hardly a tree grows, and making its nest in holes in banks.

181. Swim-bladder of a Conger Eel and Lungs of a Monkey. The swim-bladder of Fishes and the lungs of the higher Vertebrates, occupy the same position in the body and are developed in the same manner, but the one serves for flotation and the other for respiration. Darwin points out how a change of function may have been brought about in an organ by *two* organs in the body subserving for a time the same function, which function is gradually transferred from the first or older organ to the newer, and ultimately confined to the newer. He instances the case of the Dipnoan fishes, animals which use the swim-bladder for respiratory purposes alternately with the gills, and thus indicate a transition to the higher Vertebrates in which functional gills do not occur, and the lung is the sole organ of breathing. ("Origin of Species," Chap. vi.)

182. Two embryos of the Fowl, incubated about four days, and an explanatory sketch, showing the transient gill-slits which point to descent from water-breathing ancestors. ("Origin of Species," Chap. vi.)

183. Dissections of eyes of three Cephalopods and a Vertebrate (Horse). In reply to Mivart, who instanced, as one of the difficulties in the way of acceptance of the theory of natural selection, the similarity of structure in the eyes of animals so remotely related as Cuttle-fishes and Vertebrates, Darwin pointed out that though there is a general resemblance between the eyes, there are very fundamental differences. ("Origin of Species," Chap. vi.)

The lens in the eye of the Cuttle-fish is a hardened secretion of the skin, whereas that of the Vertebrate eye is composed of cells of the skin which have coalesced and become transparent. The retina of the Cuttle's eye is directly transformed from the epidermal layer of the skin, whereas that of the Vertebrate eye is developed from

the brain as a hollow outgrowth, the outer part of which becomes inpushed and converted into a cup. Moreover, the manner in which the eye of *Sepia* (C) has probably been evolved from a simple, nearly-closed pit, such as occurs in *Nautilus* (A), is indicated in the condition found in *Ommastrephes* (B). In *Nautilus* there is no lens ; in *Ommastrephes* a lens is present, but it is only partially covered over by a layer of skin ; while in *Sepia* this layer is complete and transparent, and is known as the cornea.

184. *Sesarma mülleri* and *Ocypoda arenaria*, two crabs belonging to different but related families, and both adapted for living out of the water, although the arrangements for admitting air to the gill-chamber for the purpose of aerial respiration are different in the two cases. ("Origin of Species," Chap. vi.) In *Sesarma mülleri* the carapace can be raised behind so that a slit-like opening into the gill-chamber appears above the last pair of legs ; in *Ocypoda arenaria* there is an opening, fringed with hairs, between the third and fourth pairs of legs on each side of the body. The conclusion to be drawn from these facts is that the capacity for breathing air has been acquired independently in the two crabs, the common ancestral form being capable of aquatic respiration only (Fritz Müller).

185. A small series of fruits and seeds as an illustration of Darwin's remark that the same end may be gained by the most diversified means. The end to be gained in the present instance is the conveyance of the seeds to a distance from the parent plant, and this is effected by a modification of the seed-coat or the carpel into a fluff (*e.g.* 1 and 2) or a membrane (*e.g.* 3), such as will enable the wind to carry the seeds to a distance before they reach the ground, or into hooks (*e.g.* 4, 5, and 6), which, by entanglement in the fur of passing animals, will result in the seeds being taken to a distance before they are dislodged. Or the carpels may, on drying, deliscec with such violence as to eject the seeds to a distance (*e.g.* 7 and 8), or they may become sticky when wet so as to cling to the bodies of passing animals (*e.g.* 9). Or the fruits may be of such a nature that, at all events, in a proportion of cases, the seeds are protected from the action of the digestive juices of animals which eat them (*e.g.* 10 and 11). ("Origin of Species," Chap. vi.) A much more extensive series of specimens illustrating the means of dispersal of fruits and seeds is exhibited in the Botanical Gallery.

186. A small series of Lamellibranch shells, selected to illustrate Darwin's remark on the diversity in the form of the hinge and its teeth ; an example of the same purpose being served in different

ways in more or less closely related animals. ("Origin of Species," Chap. vi.)

187. Examples of Insects which escape falling a prey to birds and lizards by their resemblance to decayed leaves, twigs and spines. Darwin's reply to Mivart's contention that "as the minute incipient variations will be in *all directions*, they must tend to neutralise one another," is to the effect that, "assuming that an insect happened to resemble in some degree a dead twig or a decayed leaf, and that it varied slightly in many ways, then all the variations which rendered the insect at all more like any such object, and thus favoured its escape, would be preserved, whilst other variations would be neglected and ultimately lost; or, if they rendered the insect at all less like the imitated object, they would be eliminated." ("Origin of Species," Chap. vii, Miscellaneous Objections.) Numerous other instances of Protective Resemblance are shown in Case 7.

188. Beak of Duck and "whale-bone." The baleen or "whale-bone" of Whales consists of a great number of laminae or plates of a horny material, which fray out at the edge into bristles and form an efficient strainer. A piece of the baleen of the Humpbacked Whale, *Megaptera boops*, is shown on the floor of this case. In answer to Mivart's question, "How to obtain the beginning of such useful development," Darwin referred to the efficient straining apparatus of the beak of the Shoveller Duck, and pointed to the beak of the Common Duck as an illustration of the manner in which the evolution of such a useful apparatus may have begun. ("Origin of Species," Chap. vii.)

189. Common Cuckoo, *Cuculus canorus*, and a clutch of eggs, including a Cuckoo's egg, taken from the nest of a White-throat. The Cuckoo's eggs are small for the size of the bird; they are laid singly in strange nests, and the young Cuckoo, shortly after hatching, ejects its foster-brothers from the nest. Darwin explains at some length how the habits of the Cuckoo, at first probably casual, may have become regular and intensified by natural selection. ("Origin of Species," Chap. viii.)

190. Cow-bird, *Molothrus bonariensis*, an American bird related to the Starlings rather than to the Cuckoos, but having the habit of laying its eggs in the nests of other birds. It lays several eggs in the strange nest, and thus has not perfected its parasitic habit to the same degree as has the Cuckoo, or even its own relative, *Molothrus pecorus*, which lays but a single egg in the nest, and thus insures

abundance of food for its offspring. ("Origin of Species," Chap. viii.)

A large series of eggs of the Cuckoo and of *Molothrus* is shown on the West Side of the Main Staircase.

191. A series of nests of Hymenoptera, leading up to the exquisitely economical honey-comb of the Hive Bee, in which, for a given size of cell, the expenditure of wax in the manufacture of the walls is reduced to a minimum, the cells being not only hexagonal in section, with single walls dividing adjacent cells, but they are disposed back to back in two layers in such a way that the three pyramidal faces of the end of one cell are walls common to three adjacent cells of the other layer. ("Origin of Species," Chap. viii.) The examples shown are a nest of the Humble Bee and those of two species of *Polistes*, a piece of the honey-comb of the Hive Bee, and an enlarged model of four of the cells.

192. Examples of melanic and albino Mammals. Occasionally there occurs in individual cases an abrupt departure from the usual coloration of a species, the colour in these cases being either very intense or even black—melanic form, or else very pale or white—albino form. ("Origin of Species," Chap. ix.) Numerous examples of melanic and albino animals are shown in Cases 16 and 15.

193. A small series of bones of the fore limb of Horse-like Ungulates showing how, by the loss of the fifth digit and the shortening of the second and fourth, a form like *Hyracotherium*, of the Eocene, may have given rise to one like *Hipparion*, of the Pliocene ; and how, by a still further reduction of the second and fourth digits to slender splint-bones, the foot of the modern Horse may have been evolved. Darwin suggests that the Tapir, with four toes on the fore limb, though not a direct survival of the ancestor of the Horse, is not very different from the common ancestor of the Tapir and Horse. ("Origin of Species," Chap. x.) For a more extensive series of remains illustrating the ancestry of the Horse the visitor is referred to one of the middle cases in the North Hall. A series of remains illustrating in like manner the line of evolution of the Elephant is on view in the Geological Department.

194. *Nautilus*, an extremely ancient Cephalopod surviving to the present day almost unchanged in character. ("Origin of Species," Chap. xi.)

195. *Lingula*, an extremely ancient type of Brachiopod surviving to the present day almost unchanged in character. ("Origin of Species," Chap. xi.)

196. *Trigonia*, a Mesozoic genus which has escaped extinction. The existing species are confined to the Australian seas ; the range of the fossil forms is, with the exception of those found in the Tertiary rocks of Australia, from the Lias to the Cenomanian (Upper Cretaceous). ("Origin of Species," Chap. xi, Extinction.)

197. (In the lower part of the case.) Specimens of *Lepidosiren*, *Polypterus*, and *Lepidosteus*, solitary modern representatives of groups which flourished in past geological periods. Darwin speaks of these as "living fossils," surviving in fresh waters, where competition is less severe than elsewhere. (It is not clear whether by "*Lepidosiren*" Darwin was referring to the *Lepidosiren paradoxa* of South America or the *Protopterus annectens* of Africa, long known as *Lepidosiren annectens* ; both are therefore shown.) *Ornithorhynchus*, the Duck-bill Platypus, is another example of Darwin's "living fossils." ("Origin of Species," Chaps. iv and xi.)

198. The Tuatara of New Zealand, *Sphenodon punctatus*, as an illustration of the imperfection of the geological record. No remains of members of the family Sphenodontidae are found later than the Jurassic period, yet *Sphenodon* is living at the present day.

199. Cast of *Archæopteryx macrura*, from the Lithographic Stone (Lower Kimmeridgian) of Eichstädt, Bavaria, as an illustration of the imperfection of the geological record. *Archæopteryx* was not known at the time the first edition of the "Origin of Species" appeared ; in the later editions Darwin observes (Chap. x) that "not long ago palæontologists maintained that the whole class of birds came suddenly into existence during the Eocene period," and remarks that the wide interval between birds and reptiles has now been partially bridged over in the most unexpected manner (Chap. xi).

Particularly impressive as an illustration of the imperfection of the geological record is the fact that the Solenhofen quarries have been worked for some two hundred years, and yet only two specimens of *Archæopteryx* have been discovered, one described in 1862 and the other in 1884. The actual specimen of which the cast is here shown is in the Geological Department of the Museum ; the later discovered specimen is in the Berlin Museum.

200. A small series of Trilobites ; an example of a group of animals becoming abruptly extinct at the close of the Palæozoic period. ("Origin of Species," Chap. xi.)

201. A small series of Ammonites ; an example of a group of animals becoming abruptly extinct at the close of the Mesozoic period. ("Origin of Species," Chap. xi.)

202. A blood-sucking Bat or Vampire, *Desmodus rotundus*, one of the animals which determine the existence of the larger naturalised quadrupeds in several parts of South America. ("Origin of Species," Chap. xi, Extinction.)

203. Some remains of the great extinct Armadillo, *Glyptodon*, of the Pleistocene of South America, for comparison with the exoskeleton of the recent Pebas Armadillo; an illustration of the succession of the same types of animal in the same areas. ("Origin of Species," Chap. xi.) In his autobiography Darwin mentions that during the voyage of the *Beagle* he had been deeply impressed by discovering in the Pampas formation great fossil animals covered with armour like that on the existing Armadillos. He could only explain the facts on the supposition that species gradually became modified, and it was this supposition, supported by numerous other items of evidence accumulated on the voyage, which gradually ripened into his theory of the evolution of species by natural selection. ("Life and Letters," Vol. i, p. 82.)

204. Photograph of the fire-screen made from the feathers of the Argus Pheasant referred to by Darwin in "Descent of Man," Ed. 2, p. 441. Lent by the University Museum of Zoology, Cambridge. (See observations on specimen **129**.)

205. (In Case **12**, Bay IX.) Specimens of *Porcellio scaber* from New Zealand. *Porcellio scaber* is a Woodlouse extremely common in Britain, and of wide distribution. In New Zealand it is especially abundant around buildings and in greenhouses, but is rarely met with in the native bush. The evidence points to the conclusion that the species has been introduced into New Zealand by the agency of man. ("Origin of Species," Chap. xi.)

206. *Cancer novæ-zealandiæ*, a crab of New Zealand, closely related to the edible crab of Britain, in illustration of the remark of Dana's quoted by Darwin ("Origin of Species," Chap. xii):—"It is certainly a wonderful fact that New Zealand should have a closer resemblance in its Crustacea to Great Britain, its antipode, than to any other part of the world." The remark refers particularly to the genera *Cancer* and *Portunus*.

207-212. Ocean-borne seeds collected in various parts of the world, as examples of one of the natural methods by which the flora of an oceanic island becomes established. ("Origin of Species," Chap. xii, Means of Dispersal.)

207. Drift seeds collected by Dr. Guppy on the beach of the Solomon Islands, in the Western Pacific.

208. Drift seeds collected on the beach of the Caroline Islands, in the Western Pacific.

209. Drift seeds collected on the beach of the Admiralty Islands, New Guinea, during the *Challenger* Expedition.

210. Four kinds of seeds picked up on the beach of Cocos Island, and presented by Dr. F. Wood-Jones, 1909. There are no plants on the island producing seeds like these. Seeds similar to these and picked up at the same time have been germinated artificially, and the explanation why the plants have not yet established themselves on the island is that the seeds are not thrown sufficiently high up the beach to find soil for germination.

211. Two kinds of seeds picked up on the beach of Cocos Island, and presented by Dr. F. Wood-Jones, 1909. These are seeds of plants which grow on the island, and it is thus uncertain whether they are drifted specimens or not. The seeds by which the species were originally introduced were evidently sea-borne from a distance.

212. Molucca Beans (*Entola* sp.), seeds of a purely tropical plant picked up on the British Coast. The single specimen in the upper box was found on the Cornish Coast near the Lizard, the other four were collected on the Orkney Islands. They were probably brought from Tropical America by the Gulf Stream.

213. Figure of the foot of a Red-legged Partridge (*Caccabis rufa*), with a clod of dry earth adhering. (Proc. Zool. Soc., 1863.) After the earth had been kept for three years, Darwin broke it up and watered it, and obtained no less than 82 young plants from the seeds contained. He points out how seeds in such accumulations of mud and earth may be carried from one country to another by birds in the course of their migrations. ("Origin of Species," Chap. xii.)

214. Hooked fruits of *Acacia elongata*. Darwin writes :—"In certain islands not tenanted by a single mammal, some of the endemic plants have beautifully hooked seeds; yet few relations are more manifest than that hooks serve for the transportal of seeds in the wool or fur of quadrupeds. But a hooked seed might be carried to an island by other means; and the plant then becoming modified would form an endemic species, still retaining its hooks." ("Origin of Species," Chap. xiii.) In this connection the seeds (or, more correctly, the fruits) of the rosaceous plant *Acacia* are interesting as having frequently been found adhering to the feathers of the Albatross, which may thus be a means of introducing the plant into oceanic islands.

215. Seeds taken from the crop of Pigeons (a) in the Admiralty Islands, and (b) in the Solomon Islands. The crop is a part of the alimentary tract in the lower region of the neck of a bird in which food is stored until it is passed on to the gizzard. No digestion takes place in the crop, and seeds may be stored in it unchanged for many hours, during which the bird may fly or be blown in a gale from a continent to a distant island. The accidental death of the bird on arrival might well lead to the seeds germinating and thus establishing on the island plants previously unknown there. ("Origin of Species," Chap. xii, Means of Dispersal.)

216. (On the shelf in the lower part of the case.) A Double Coco-nut or Coco-de-mer, *Lodoicea seychellarum*. Double Coco-nuts are well known in consequence of their being brought home by sailors as curiosities. They are found floating in all parts of the Indian ocean, but the plant itself lives only in the Seychelles Islands. The floating nuts were known to travellers long before the Seychelles were discovered. Recent examination of floating specimens shows them to be hollow, and incapable of germination, so that as an example of the spread of plants by means of the sea the case is not a good one. On the other hand the Coco-nut, *Cocos nucifera*, is equally common, or more so, on the surface of the ocean, and those cast up on distant islands germinate readily.

217. Two ice-borne stones (erratics) from the Boulder Clay of Norfolk. Darwin comments on the fact that since icebergs can carry stones and deposit them at a distance, it is at least possible that they may carry also seeds of plants from a mainland and leave them on some distant island in a condition still capable of germination. ("Origin of Species," Chap. xii.)

218. Dragon-flies of three species, caught at Cocos Island and presented by Dr. F. Wood-Jones, 1909. At certain times of the year, generally after a North wind, dragon-flies are very numerous on the atoll. Yet none of them have been bred on the island; all are immigrants from some mainland, the nearest of which is several hundred miles away. Dragon-flies cannot breed on the island because there are no open tracts of fresh water in which the larval stages of the life-history may be passed.

219. A Locust, *Acridium peregrinum*, one of the locusts mentioned by Darwin as swarming over the island of Madeira in 1844. ("Origin of Species," Chap. xii, Means of Dispersal.) The importance of such visits, Darwin points out, lies not only in the devastation

of the herbage, but in the introduction of new kinds of plants arising from undigested seeds dropped on the island by the locusts.

220. A Locust, *Acridium peregrinum*, one of the swarm that visited Las Palmas, Grand Canary, in 1908. Fifty tons were killed and paid for by weight, and it was estimated that this constituted only one-fourth of the swarm. Allowing 15 specimens to the ounce, there would be about 107,500,000 specimens in the total of 200 tons.

221. *Dytiscus* and *Colymbetes*, water-beetles such as might be instrumental in the conveyance of fresh-water molluscs to distant islands. Darwin speaks of *Dytiscus* caught with the Fresh-water Limpet, *Ancylus*, adhering to it, and he records the capture of a *Colymbetes* on the *Beagle* at a distance of forty-five miles from the nearest land. ("Origin of Species," Chap. xiii, Fresh-water Productions.)

222. Shells of the Fresh-water Limpet, *Ancylus fluviatilis*. Darwin mentions the possibility of the spread of this and other fresh-water molluscs by their adhering to water-beetles and ducks, which may fly across the sea to distant parts. ("Origin of Species," Chap. xiii.)

223. Shells of three species of *Cyclostoma*, land molluscs with an operculum or lid which so effectually closes the mouth of the shell that the animal is not injured by immersion in sea-water. Entangled in drift-wood, the animals may float to distant parts, and may establish themselves on any island upon which they may be cast up. ("Origin of Species," Chap. xiii.)

224. Shells of the Garden Snail, *Helix aspersa*, and the Edible Snail, *Helix pomatia*. These molluscs, though not provided with an operculum, close the mouth of the shell at certain times of the year by an epiphragm, a secretion which hardens in contact with air. Darwin ascertained by experiment that the Edible Snail, when thus sealed, was uninjured by immersion in sea-water for twenty days. ("Origin of Species," Chap. xiii.)

225. A selected series of flightless Beetles from Madeira. Darwin accounts for the occurrence of flightless beetles on oceanic islands as due to natural selection combined probably with disuse of the wings. The individual insects which use their wings to any great extent will be liable to be blown off the island and destroyed at sea, whereas those which, through indolence or through the wings being less perfectly developed, venture less in the air will remain on the island

and perpetuate the deficient mechanism of flight. ("Origin of Species," Chap. v, Effects of Use and Disuse.)

In some island beetles, *e.g.*, *Blaps gages*, in the top row, the wing-covers are fused together. ("Origin of Species," Chap. xiii, Inhabitants of Oceanic Islands.)

226. Specimens of *Melissius eudoxus*, of St. Helena, a Beetle of interest in being an apterous species of the family Dynastidæ, the other members of which are winged.

227. Four species of Beetles of the sub-family Ectenorrhinides, which includes numerous flightless beetles found in oceanic islands, and a single continental form, *Brachyrhynchus subsignatus*, which is winged.

228. A series of endemic land shells of Madeira, in illustration of Darwin's remark that "Madeira is inhabited by a wonderful number of peculiar land shells, whereas not one species of sea shell is peculiar to its shores." ("Origin of Species," Chap. xiii.)

229. Five species of Bats from Oceanic Islands. Darwin notes that although terrestrial mammals do not occur on oceanic islands, bats are found, and in many instances they are peculiar to an island or a group of islands. The explanation is that the ancestors of the island bats were stragglers from the mainland, carried probably during a gale, and that their descendants have gradually assumed their present distinctive characters in relation to their surroundings. ("Origin of Species," Chap. xiii.) Of the specimens shown, *Pteropus rubricollis* and *Pteropus vulgaris* are endemic in Mauritius and Bourbon, *Pteropus psilaphon* occurs only in the Bonin Islands, *Pteropus keraudreni insularis* is peculiar to the Caroline Islands, and *Notopteris macdonaldi* to the Viti Archipelago.

230. A series of Black Grosbeaks peculiar to the Galapagos Islands, and first discovered by Darwin during the voyage of the *Beagle*. Darwin noted that in several cases different species inhabited different islands of the archipelago, and he further remarked that the nearest relatives of these birds are to be found on the mainland, which one would hardly expect to be the case had the endemic species of the islands been special creations instead of modified descendants of birds which had immigrated from the mainland. ("Origin of Species," Chap. xiii.) In his autobiography Darwin states that it was the peculiarity of the Galapagos fauna, among other things, that first influenced him to question the immutability of species, and started a train of thought which found

expression in the "Origin of Species" some twenty-four years later.

231. A series of Frogs and Tree-frogs from Madeira, the Azores, Mauritius and New Caledonia. ("Origin of Species," Chap. xiii, Absence of Batrachians on Oceanic Islands.) The statement that "frogs have been introduced [*i.e.* by man] into Madeira, the Azores, and Mauritius, and have multiplied so as to become a nuisance" does not, except in the case of the Azores, appear to be supported by evidence. The *Rana esculenta* found in Madeira is a widely-distributed frog of Europe, Asia, and North Africa, and the variety of Tree-frog found in Madeira (*Hyla arborea meridionalis*) is a form common in N.W. Africa. Frogs introduced into the island by man would be more likely to have been brought in by the Portuguese than by the Moors, and one would therefore expect rather a Portuguese variety of Tree-frog than the African. The same Tree-frog also occurs in the Canary Isles. The Frog of Mauritius (*Rana mascariensis*) occurs also in Madagascar, the Seychelles, and other islands, and there is no evidence of its introduction by human agency. On the other hand the Tree-frog of New Caledonia has been definitely ascertained by Layard to have been brought in from Australia.

232. *Galaxias attenuatus*, quoted by Darwin as an important case of a fish occurring in the fresh waters of parts of the world as widely remote as Tasmania, New Zealand, Falkland Islands, and the mainland of South America. ("Origin of Species," Chap. xiii, Geographical Distribution, Fresh-water Productions.) Recent study of the family Galaxiidae has shown that, as in the case of the Salmonidae, the fishes are marine fishes of which some have adopted a purely fresh-water habit. *Galaxias attenuatus*, however, although found in brackish and fresh water, breeds in the sea, and its wide distribution is therefore less remarkable than was formerly supposed.

233. A small series of Alpine plants in illustration of Darwin's remark on the similarity of the mountain plants of distant parts of the world, and the absence of such plants from the vast tracts of low ground between. ("Origin of Species," Chap. xii.) *Saxifraga nivalis* and *Saxifraga rivularis* occur on the mountains of Europe, Asia and America, *Gentiana verna* on the mountains of Europe and Asia, and *Gentiana nivalis* on those of Europe and America; yet, except in arctic regions, these plants do not grow below two or three thousand feet above the sea level.

234. Bones of the feet of the Roebuck, Fallow Deer and Ox,

illustrating the generalisation that vestigial structures, probably useless to the possessor, are of value as indicating affinity with animals in which the parts are well developed. The bones of the second and fifth digits are wanting in the Ox; in the Roebuck and Fallow Deer they are present as vestiges, and these vestiges serve to show the affinity that exists between the ruminants and the "pachyderms." ("Origin of Species," Chap. xiv.)

235. Lower jaws of various Marsupials, showing the inflection of the angle, which, prevailing as it does throughout many and different species which have very different habits of life, is valuable evidence of descent from a common ancestor. ("Origin of Species," Chap. xiv, Classification.)

236. Skulls of the Viscacha and *Phascolomys*, showing general resemblance. These animals are cited by Darwin ("Origin of Species," Chap. xiv) in illustration of G. R. Waterhouse's generalisation that when an animal of one group exhibits affinity with another group, the resemblances are general and not special. The Viscacha, for instance, resembles no Marsupial in particular, but Marsupials generally, and the conclusion to be drawn is that the Viscacha has departed from the ancestral form common to the Rodents and Marsupials to a less extent than have other Rodents. Similarly with regard to the Marsupial *Phascolomys*, the Wombat, in its relation with the Rodents. Darwin observes, however, that "it may be strongly suspected that the resemblance is only analogical, owing to the *Phascolomys* having become adapted to habits like those of a Rodent."

237. Electrical Organs in Fishes. Darwin mentions the occurrence of electrical organs in fishes as one of the difficulties in the way of accepting his theory, because the fishes possessing them are not near relatives; because the electrical organs occur in different parts of the body, and differ in the arrangement of the plates, and in the nerve supply; and because it is difficult to see by what graduated steps these organs have been developed in each separate group of fishes, the organ being of no utility for defensive or offensive purposes until fully formed. ("Origin of Species," Chap. vi.) The specimens shown are the Electric Cat-fish, *Malopterurus electricus*; Electric Eel, *Gymnotus electricus*; Electric Ray, *Torpedo hebetans*; and Skate, *Raia batis*.

238. Examples of Insects of two related families of Hymenoptera to show that organs that are constant in form in one family may be of diverse forms in another. ("Origin of Species," Chap. xiv.) In

the upper specimens, of the family Ichneumonidæ, the antennæ are constant in structure, being long and whip-like. In the lower specimens, of the family Tenthredinidæ, the antennæ differ much, and the differences are of subordinate value in classification.

239. Examples of closely allied Insects differing more in their larval than in their mature stages—three species of Shark Moth (*Cucullia*), and two species of Dagger Moth (*Acronycta*), with the caterpillars of each. ("Origin of Species," Chap. xiv.)

240. A Leptalid Butterfly, *Moschnoneura methymna*, bearing a mimetic resemblance to an Ithomiine Butterfly, *Scada phyllodoce*. Both occur in the same parts of South America. The two Butterflies are not closely related, a detailed comparison showing that the resemblance is one of shape and colour mainly. The mimicking Butterfly (*Moschnoneura methymna*) differs considerably in appearance from its relatives, a typical example of which, *Pseudopieris nehemia*, is here shown for comparison. The Ithomia is distasteful to predaceous birds, and the Leptalis is supposed to enjoy a freedom from persecution by its resemblance to the Ithomia. The case is instanced by Darwin as one in which "close external resemblance does not depend on adaptation to similar habits of life, but has been gained for the sake of protection." ("Origin of Species," Chap. xiv, Analogical Resemblances.) Numerous other instances of such protective resemblance are shown in Case 7.

241. A series of Wasps and Bees, insects that are avoided because of their stings, mimicked by Flies, Moths, Beetles and Neuropterous insects not provided with such weapons. ("Origin of Species," Chap. xiv.) Of particular interest are the two Beetles in the top row, the hinder patches of orange and black being situated on the abdomen in *Hesthesia*, and on the elytra in *Tragocerus*. Other instances are shown in Case 7.

242. Boring Molluscs, showing similarity of external form. The specimens to the right (*Petricola pholadiformis* and *Coralliophaga coralliophaga*) are closely related molluscs which resemble respectively the genera *Pholas* and *Lithodomus* (specimens to the left), although they are not related to these genera, and although there is no close affinity between *Pholas* and *Lithodomus*. ("Origin of Species," Chap. xiv.)

243. A Mouse, a Shrew and an *Antechinus*, belonging respectively to the Rodentia, Insectivora and Marsupialia, as examples of unrelated animals having the same general appearance. The resemblance is attributed to adaptation for similarly active move-

ments through thickets and herbage, and concealment from enemies. ("Origin of Species," Chap. xiv, Analogical Resemblances.)

244. Skulls of Dog and Thylacine, animals belonging to the Carnivora and Marsupialia respectively, to show the general resemblance in the teeth, attributable to the carnivorous habits of the two animals. The resemblance is a general one only; a detailed comparison of the teeth shows important differences. ("Origin of Species," Chap. xiv, Analogical Resemblances.)

245. Diagrams of the Skeleton of the Fore Limb of Reptiles, Birds, and Mammals, showing that however different the habits of life of these animals, the fundamental type of construction of the limb-skeleton is the same in all. ("Origin of Species," Chap. xiv.) The humerus is coloured blue, the radius and ulna red, the carpal bones green, and the metacarpal bones and the phalanges yellow. Equivalent digits are denoted by similar numerals. Actual specimens of these limbs are to be seen in the cases on the opposite side of the Hall. "How inexplicable is the similar pattern of the hand of a man, the foot of a dog, the wing of a bat, the flipper of a seal, on the doctrine of independent acts of creation! How simply explained on the principle of the natural selection of successive slight variations in the diverging descendants from a single progenitor!" ("Animals and Plants under Domestication," Chap. i.)

246. Preparations of the mouth-parts of a Beetle, a Sphinx Moth and a Bee, with diagrammatic sketches, to show how remarkably different in size and shape are the organs for sucking and biting which have been formed by modification of the mandibles and two pairs of maxillæ. ("Origin of Species," Chap. xiv, Morphology.)

247. The wild Chrysanthemum of China, *Pyrethrum sinense*. This is the wild plant from which all the cultivated varieties known as "Chrysanthemums" have by assiduous cultivation and artificial selection been derived. ("Animals and Plants under Domestication," Chap. xi.)

248. Primrose and Purple Loosestrife. The flowers of the Primrose are of two kinds, one with high stigma and low anthers, and the other with low stigma and high anthers. Darwin, by a series of experiments, found that better seed is produced by pollinating a high stigma flower with pollen from high anthers, and a low stigma with pollen from low anthers, than is produced by pollinating a stigma from anthers at a different level to itself. (Journ. Linn. Soc. 1862.) Darwin also discovered that in the Loosestrife

(*Lythrum*) the stigma and anthers occur at three levels in different flowers. (Journ. Linn. Soc. 1864.) See also specimens in Case 19.

249. (In the lower part of the left-hand half of the case.) A Sea Iguana, *Amblyrhynchus cristatus*, a lizard of the Galapagos Archipelago, which lives partly on the sea shore and partly in the sea. It is sluggish in its movements, and feeds on sea-weed. ("Naturalist's Voyage round the World," Chap. xvii.)

250. A hybrid between the Common Pheasant, *Phasianus colchicus*, and the Ring-necked Pheasant, *Phasianus torquatus*. This hybrid is cited by Darwin as one of the few hybrids that are fertile. ("Origin of Species," Chap. ix, Degrees of Sterility.) Many other examples of Pheasant hybrids are shown in the North Hall.

251. A female Pheasant, *Phasianus colchicus*, partly albino, assuming male plumage. Presented by H.R.H. the Prince of Wales, 1909. Cases of female birds exhibiting male characters, such as long tail-feathers, hackles, comb, spurs, voice, and pugnacity, are instanced by Darwin in "The Descent of Man," Chap. viii. In most cases the phenomenon is associated with old age, or with disease of, or injury to the generative organs.

SPECIMENS ILLUSTRATING DARWIN'S RESEARCHES ON PLANTS.

In Case 19, a table-case near the Owen statue, is exhibited a series of models, drawings and specimens illustrating the Fertilisation of Flowers. Instances are given of flowers cross-pollinated by the wind, and by insects; flowers in which self-pollination is impossible because the anthers and stigma of the same flower ripen at different times; flowers in which there are differences in the height of the anthers and stigma in different flowers of the same species, as *Primula* and *Lythrum*; and flowers in which cross pollination by insects is favoured by special floral mechanisms, as the Sage and Orchids. The modern development of the study of this subject was initiated by Darwin's investigations, published in "The Various Contrivances by which Orchids are fertilised by Insects," 1862, and "The Effects of Cross and Self Fertilisation in the Vegetable Kingdom," 1876.

In Case 20, a table-case near the last, is exhibited a series of models, drawings and specimens of Insectivorous Plants, such as the Bladderwort, Pitcher Plant, Butterwort, Sundew and Venus' Fly-trap. Darwin's book, "Insectivorous Plants," 1875, contains the first detailed account of the remarkable method of nutrition characteristic of these plants. A copy of the book is shown in Case 3.

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BRITISH MUSEUM (NATURAL HISTORY)

SPECIAL GUIDE No. 5

GUIDE TO THE EXHIBITION
OF
ANIMALS, PLANTS,
AND
MINERALS
MENTIONED IN THE BIBLE



SECOND EDITION

LONDON
PRINTED BY ORDER OF THE TRUSTEES
OF THE BRITISH MUSEUM

1911

[PRICE SIXPENCE]



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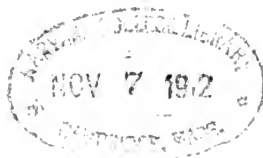


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PREFACE.

It was thought by the Trustees of the British Museum that an Exhibition of Animals, Plants, and Minerals mentioned in the Bible would form an interesting supplement to the literary and historical Biblical Exhibition which has been arranged at Bloomsbury for the Tercentenary of the Authorised Version, and instructions were given for its preparation. The result is the collection now placed in one of the bays of the Central Hall of the Natural History Museum.

The Animals and Minerals, respectively, have been selected, arranged, and labelled by Mr. Lydekker and Dr. Herbert Smith, under the general supervision of the Keepers of Zoology and Mineralogy; the Plants have been selected, arranged, and labelled by Dr. Rendle, the Keeper of Botany.

The zoological and botanical parts of the present guide-book are virtually reprints of the exhibited labels, and the information given on the latter has been to a considerable extent derived from the late Dr. H. B. Tristram's "Natural History of the Bible," the first edition of which was published in the year 1867.

As regards the Biblical Minerals, scarcely any of them were found in Palestine itself or were brought from localities now known; they are not considered in Dr. Tristram's work, and, notwithstanding all that has been written about them during many centuries, there is still great uncertainty as to the original signification of the Hebrew and Greek names. As the subject presents much difficulty, I have contributed to the guide-book a short essay showing how modern interpretations of the ancient names of Biblical Minerals have been deduced.

L. FLETCHER,

Director.

BRITISH MUSEUM (NATURAL HISTORY),

December 21st, 1911.

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GUIDE TO ANIMALS, PLANTS, AND MINERALS MENTIONED IN THE BIBLE.

I.—ANIMALS.

THE proper identification of the various animals mentioned in the Old Testament is in many cases a matter of extreme difficulty ; and this for several reasons. For in a number of instances we have even now no definite clue as to the real signification of the old Hebrew names of animals mentioned in the sacred text ; and when the authorised translation was made three centuries ago the difficulty was of course very much greater, owing to the imperfect knowledge of natural history at that time. Since that date important clues have been obtained by correlating the Hebrew words with current Arabic and Coptic names of animals, and in this way many of the difficulties have been more or less satisfactorily solved, although in other cases little or no progress has been made ; and it seems probable that the signification of some of the Hebrew animal names will always remain an enigma. A further difficulty arises from the circumstance that some of the Hebrew names appear to refer to purely mythical creatures.

In this country the pioneer in research of this subject was the late Canon H. B. Tristram, whose work on "The Natural History of the Bible" was published by the Society for Promoting Christian Knowledge in 1867. In the case of mammals it happened, however, that the author was under the impression that certain large species of North African antelopes, such as the bubal hartebeest, the addax, and the white, or sabre-horned, oryx, ranged into Syria, whereas they do not, as a matter of fact, occur anywhere east of the Nile. This

rendered some of the Canon's identifications of Hebrew Scriptural names incorrect. It may be added in this connection that it is still uncertain whether the Arabian Oryx (*Oryx beatrix*) of the Syrian and Arabian deserts may not be one of certain unidentified animals, such as the "Pygarg," mentioned in the Bible.

Since many of the animals referred to in the Bible are of large bodily size, it has been found impracticable to show them in the present exhibition otherwise than by specimens of their heads and horns or by pictures.

Before proceeding to notice the various species which can be more or less satisfactorily identified, a few words may be devoted to certain names which either cannot be identified or which are not worthy of special labels. Among those of the first type is "Satyr," which probably relates to a purely mythical animal, although it has been proposed to connect the name with the great dog-headed Baboons (*Papio*) of Egypt and Arabia. Again, the bird indicated by *shahaph*—translated "Cuckoo" in the Authorised Version—cannot be identified.

For "Weasel" the reader may refer to the heading MOLE. The word rightly translated "Mouse" appears to be generally used in a wide sense, although in one instance it clearly refers to the Continental Short-tailed Field-Mouse (*Microtus*, or *Arvicola, agrestis*). "Hare" relates to the common Syrian species, *Lepus syriacus*.

In connection with the words "Cock" and "Hen," which occur in the New Testament, it may be mentioned that there is no reference in the Old Testament to domesticated poultry, which were probably first introduced into Judea after the Roman conquest.

As regards Fishes, of which there is frequent mention in the Bible, there is, in most cases at any rate, no possibility of making any specific identification, although "Eel" doubtless refers to one or both of the two species found in Syrian waters.

HORSE. MULE. ASS.

Horses were used in Biblical times chiefly in war, and were then a comparatively recent introduction. No reference is made to Mules till the time of David; but after that date Horses and Mules are often mentioned together. In some cases the word translated "Dromedaries" really means Mules. The word "Ass" refers to the well-known domesticated animal, whose wild relative (*Equus asinus africanus*) inhabits Nubia; but "Wild Ass" indicates a very different animal, the Syrian Onager (*E. onager hemippus*), which

still inhabits Palestine, and belongs to a group of species in some degree connecting the Horse with the Ass. The Onager is represented in the case on the left side of the Bay by pictures. The "pale Horse" of Rev. 6, the translation of the Greek *chlōros hippos*, probably indicates a dun Horse, a type regarded in some countries as very ancient, but of bad quality; while the "red Horse" of the same chapter, the translation of *purros hippos*, probably denotes a chestnut.

UNICORN.

The Hebrew word *rēm*, translated "Unicorn" (Job 39, 9-12), indicates a two-horned animal; the proper rendering of the sentence "the horns of unicorns" (Deut. 33, 17) being "the horns of a unicorn." It is probable that the animal referred to is the extinct Wild Ox or Aurochs (*Bos taurus primigenius*), which, as indicated by Assyrian sculptures, of one of which an illustration is shown in the case, was living in Asia Minor in Biblical times. By Dr. Duerst the Syrian Aurochs is considered a distinct species.

If this be correct, the "wild bull in a net" (Isa. 51, 20) must refer to a different animal—the Hebrew *tō*—although the species cannot be determined. It may be mentioned that at the present day the word *rim*, probably the equivalent of *rēm*, is applied by the Arabs to a N. African species of Gazelle; the name having perhaps been transferred to that animal after the extermination of the Aurochs. A cast of a skull of the latter animal is shown in the North Hall, and a photograph of another skull is exhibited in the left-hand wall-case.

CATTLE.

Cattle, which were used in Biblical times for ploughing, treading-out corn, and for draught, as well as for dairy purposes, food, sacrifice, etc., are referred to by several names, indicative of sex, age, etc. Like those of ancient Egypt (Fig. 1), the Cattle of Palestine were derived from the Humped Ox or Zebu of India, of which a stuffed specimen is exhibited in the North Hall; but while in some instances the hump, as shown in two of the illustrations in the left-hand wall-case, was retained, in other instances, as in the group of Oxen treading-out corn, it had been eliminated by selection. A skull, with the horns, of the ancient Egyptian Ox is shown in the upper part of the case; and below this is an illustration of the Indian Zebu.

FIG. 1.



ANCIENT EGYPTIAN OX.

FIG. 2.



SYRIAN FAT-TAILED SHEEP.

From Murray's "Bible Dictionary."

SHEEP.

The ordinary Sheep of Palestine belong to the white fat-tailed breed, in which the rams carry large horns (Fig. 2). From the mention of "the fat, and the rump" (Ex. 29, 22) it seems probable, however, that the fat-rumped breed, commonly known as the "Hedjaz Sheep," of which a mounted specimen is shown in the North Hall, was also found in Syria in Biblical times. Sheep akin to European breeds are stated by Tristram to occur in Syria. The earliest breed in Egypt appears to have become extinct before the time of the Pharaohs, and was a long-legged Sheep, with spiral horns, lop ears, a fringe on the throat of the rams, and a long tail; the colour being light, light with dark blotches, or wholly dark. It was related to the Maned Abyssinian and Hausa Sheep, of which specimens are shown in the North Hall. During the Pharaonic epoch this Sheep was replaced by a fat-tailed breed, in which the limbs were shorter, the tail was thickened, and flattened, and the horns generally of the so-called "Ammon" type, while the coat was probably woolly. A skull of this Sheep, from an Egyptian tomb, is exhibited in the upper part of the case.

GOAT.

Several Hebrew words are translated "Goat," "She-Goat," or "Wild Goat" in the Bible. Of the local domesticated breeds, the Syrian, or Mambar, Goat is tall and long-limbed, with very long ears, and shaggy silky black hair. Skulls of this breed from an Egyptian tomb are exhibited in the upper part of the case. In the Egyptian, or Theban, Goat the limbs are long, the horns short or wanting, the head small, with a convex profile, and the beard generally absent; the short hair is usually reddish brown, tending to yellow on the limbs, but may be slaty grey or spotted. Specimens may be seen in the North Hall. The word *ya'él*, translated "Wild Goat" (Job 39, 1), probably indicates the Beden or Sinaitic Ibex (*Capra nubiana sinaitica*); but it is possible that this or another word may in some instances refer to the Wild Goat (*Capra hircus ægagrus*) of Mount Ararat. A picture of the Sinaitic, or Nubian, Ibex is exhibited in the case.

CHAMOIS.

The Hebrew *zémer*, which appears akin to the Arabic *zamar*, indicates a mountain animal, and is translated "Chamois" in

Deut. 14, 5. But that species is unknown east or south of the Taurus range, and it has been suggested that the animal referred to is the African Wild Sheep, or Udad (*Ovis lervia*, or *tragelaphus*), which inhabits the mountains of Upper Nubia, although not ranging east of the Nile. Possibly it may be Gmelin's Sheep (*Ovis orientalis*), which occurs in South-eastern Asia Minor, unless indeed the original rendering is correct.

ROEBUCK. HART. HIND. FALLOW DEER.
"PYGARG."

Much confusion exists in the translation of the Hebrew words thus rendered. For instance *çēbī*, equivalent to the Arabic *zebi*, is translated "Roebuck" in Deut. 12, 15, but really signifies the Dorcas Gazelle (*Gazella dorcas*), which abounds on the plains of Syria, and perhaps also the Palestine Gazelle (*G. merrilli*). On the other hand, *yahmūr*, translated "Fallow Deer" in Deut. 14, 5, signifies the Roebuck (*Capreolus caprea*), which still inhabits the woods of Gilead. It has been identified with the Bubal Hartebeest (*Bubalis bosclaphus*), but that species is unknown in Asia or east of the Nile. *Ayyāl*, translated "Hart" in Deut. 12, 15, 22, indicates the male Fallow Deer (*Cervus dama*), which is still found on Mount Tabor; "Hind" being the female of the same species. The animal indicated by "Pygarg," the translation in Deut. 14, 5, of the Hebrew *dishōn*, is uncertain. *Pygargus* was used by Herodotus for a North African Antelope with a white rump-patch; and if the Hebrew "Pygarg" really indicates a white-rumped animal, a species allied to the Goitred Gazelle (*Gazella subgutturosa*) of Persia might be referred to. Heads, horns, and antlers of some of the species mentioned above are exhibited in the upper part of wall-case on the left.

CAMEL. DROMEDARY.

Camels of the single-humped Arabian kind (*Camelus dromedarius*) were employed in ancient Palestine for draught, riding, and in war, and their hair was woven into garments. Dromedaries are swift riding Camels. In some instances "Dromedary" in the Bible indicates a superior breed of Horse. Camels do not appear on the Egyptian monuments, whence it has been inferred that they were unknown in ancient Egypt; but they are mentioned in the Anastasi Papyrus (No. 1), p. 23, written about 1300 B.C. Into the rest of North Africa they do not appear to have been introduced till the third century of our era.

SWINE.

As indicated by the expression "Boar out of the wood" (Psalm 80, 13), the forest districts of Palestine sheltered droves of wild Swine (*Sus scrofa ferus*) in Biblical times, as many of them do at the present day. In Gospel times domesticated Swine, although abhorrent to the Jews, were kept, and probably eaten, around, if not in, Palestine.

BĔHĒMÔTH.

Bĕhēmôth (Job 40, 15), the Hebrew equivalent of the Coptic *pehemaut*, meaning "Water-Ox," in many instances at any rate, undoubtedly denotes the Hippopotamus (*Hippopotamus amphibius*),

FIG. 3.



THE SYRIAN HYRAX = THE "CONEY" OF THE BIBLE.

which, although now banished to Upper Nubia, formerly inhabited the lower reaches of the Nile. There is, however, no record of the occurrence of the species in Syria or Palestine during the historical period. The term may also be applied to any large animal.

"CONEY."

Realising that the Hebrew word *sháphán* (the hider) indicated a small animal living in holes among rocks, the translators of the Bible rendered it "Coney" (Lev. 11, 5, and Psalm 104, 18), the word then in general use for the Rabbit (*Lepus cuniculus*). Since the word "Coney" has now dropped out of general use (surviving only in legal documents), it is frequently supposed to be the proper name of the animal referred to in the Bible. The *sháphán* has been

identified with the Syrian Hyrax (*Procavia*, or *Hyrax, syriaca*), Fig. 3, an animal which has nothing to do with the Rabbit, or indeed Rodents generally. On the contrary, it is a distant relative of the Rhinoceros and Elephant, having somewhat Rhinoceros-like molar teeth, and the toes terminating in broad, hoof-like nails. In Lev. 11, 5, the *sháphán* is stated to chew the cud, and since the Hyrax does not do so, the identification of the latter with the former has been questioned by Dr. H. C. Chapman (*Proc. Philadelphia Academy of Sciences*, vol. lvi., p. 479, 1904). The objection, however, is invalid, since there is no small animal with the habits of a Hyrax or Rabbit which ruminates; the idea that such animals possess this function having probably arisen from the rapid movements of their lips.

A stuffed specimen and a skull of the Syrian Hyrax are exhibited.

LION.

Although Lions (*Felis leo*), to which there are many allusions in the Bible, have been long since exterminated in Palestine, they still abound on the banks of the Euphrates between Bussora and Bagdad—where they dwell in the oak-forests, and feed largely on Wild Swine—as well as in the marshes of Babylonia. In Biblical times Lions were probably numerous throughout Palestine and Syria generally.

LEOPARD.

The Hebrew word *námér*, the equivalent of the Arabic *ním'r*, which is translated "Leopard" in the Bible (Jer. 5, 6), probably indicates two distinct kinds of animals, namely, the true Leopard (*Felis pardus*), in which the black markings on the body take the form of rosettes, and the Hunting-Leopard (*Cynælurus jubatus*), in which they are solid spots. Leopards are still found in the Lebanon; and Hunting-Leopards are used at the present day for coursing Gazelles in Syria. Both species are known in India as *chita*, a name which, like *ním'r*, means "spotted."

CAT.

The word "Cat" occurs but once, in the Apocrypha (Baruch 6, 22), where it is believed to indicate Wild Cats, which are represented in Syria by a race of the European species (*Felis catus moreæ*). Mention is, however, made of Cats, *cathod*, in the Welsh Bible (Isa. 34, 14).

DOG. GREYHOUND. WOLF. FOX.

The Hebrew *kéleb*, translated "Dog" in the Bible, refers for the most part to the hordes of Pariah Dogs (Fig. 4) that haunt all Eastern cities, where they are useful scavengers. The Hebrew *zarzîr mothnayim*, signifying "girt about the loins" (Prov. 30, 31), may be rightly translated "Greyhound," although other renderings have been suggested. If so, the Slugh, or Gazelle-Hound, of the Bedouin of

FIG. 4.



A TURKISH PARIASH DOG.

Arabia and Syria is probably the Scriptural Greyhound (Fig. 5). These Dogs are often girdled by their owners in order to prevent them from over-eating and becoming fat. The Afghan Greyhound is an allied, but more hairy, breed (Fig. 5). Wolves (*Canis lupus*) are still common in Palestine, as are Jackals (*C. aureus*) and Foxes (*Vulpes alopecurus niloticus*). The "Foxes" (Hebrew *shú'al*) of the Old Testament (Judges 15, 4) are certainly Jackals, but the use of the former word in the New Testament, as the translation of the Greek *alōpēx*, is probably correct.

BEAR.

The Syrian Bear (*Ursus arctus syriacus*), which is a grey phase of the typical Brown Bear of Europe, still inhabits the mountains of Palestine, and in Biblical times, as is evident from 2 Kings 2, 24, was doubtless distributed over the greater part of the country.

FIG. 5.



SLUGHİ (A) AND AFGHAN GREYHOUND (B).

HYÆNA.

The Valley of Zeboim (1 Sam. 13, 18) is still called by Arabs Shukh-ed-Dubba=the Gorge of the Hyæna, and is thus believed to refer to the Striped Hyæna (*Hyæna striata*), which is now common throughout Syria. The Hebrew word *çábûa'*, which, with the word *'ayîl* preceding it, is rendered (Jer. 12, 9) a "speckled bird" in the Authorised Version, may indicate the Hyæna; and the same may be the case with the "doleful creatures" (*ôhîm*) of Isa. 13, 21.

"FERRET."

"Ferret," the rendering in Lev. 11, 30, of the Hebrew *ănâqâh*, is one of the most unfortunate translations in the Bible, as the animal referred to is probably one of the group of Lizard-like Reptiles known as Geckos, such as the Fan-footed Gecko (*Ptyodactylus lobatus*) and the Common Gecko (*Tarentola mauritanica*), which frequent the walls and ceilings of houses in Palestine and Egypt. "Hedgehog" and "Toad" have also been suggested as proper renderings. Specimens of Geckos are shown.

"MOLE."

Two words are translated "Mole" in the Bible, but since there are no true Moles in Palestine, it is evident that in neither instance is the rendering correct. The first word, *tinshémeth* (Lev. 11, 30), probably indicates the Chamæleon; but the second, *hâphôr-pérôth* or *hâphôr pérôth* (Isa. 2, 20), seems to refer to a species of Mole-Rat allied to the *Spalax typhlus* of Eastern Europe and Egypt. These animals have somewhat the habits of Moles, but feed on roots instead of worms, and belong to the Rodent order of Mammals. The "Weasel" of Lev. 11, 29, may also be the Mole-Rat.

ELEPHANT. IVORY.

Indian Elephants (*Elephas maximus*) were first brought to Palestine by Antiochus Epiphanes, king of Syria, by whom they were employed in war. Possibly these Elephants came from Mesopotamia, as there is historical evidence that the Indian species inhabited that country in Assyrian times. On the other hand, ivory, which was supplied either by the caravans of Dedan, or brought, together with Apes and Peacocks, by the navy of Tarshish (1 Kings 10, 22), was probably the product of *Elephas africanus*. Egyptian merchants traded for ivory to Barygaza, the port to which were carried the products of India from Ozene. As to the locality of Tarshish see PEACOCK (p. 15).

WHALE. LEVIATHAN. DRAGON.

The Hebrew *tannîn*, translated indifferently as "Dragon," "Sea-Monster," "Serpent," or "Whale," seems, in one instance at any rate (Lam. 4, 3), to indicate a member of the Cetacean order.

"Leviathan" also appears in one passage (Psalm 104, 26) to indicate a Whale. Jonah's Whale is rendered in the New Testament as *kētos*, the Greek term for any Whale, but in the Ethiopic Bible appears as *anbar*, the Arabic name for ambergris, and thus for the Sperm-Whale (*Physeter macrocephalus*), by which it is produced. Evidence has been adduced by Dr. Paul Haupt (*Proc. Amer. Phil. Soc.*, 1907, vol. xlv., p. 151) to show that Jonah's Whale was a Sperm-Whale.

It may be of interest to mention that the material first called amber was the perfume now termed ambergris; at a later period the name amber was transferred to the fossil resin which now goes by that designation, and the substance first termed amber was distinguished as ambergris (*i.e.* grey amber).

On the other hand, in Job 41, 1, "Leviathan" signifies the Timsa, or Nile Crocodile (*Crocodilus niloticus*), which, at least at one time, inhabited Syria as well as Egypt; and the word *tannin*, translated "Dragon," also refers in several instances to the same reptile.

"BADGER."

The Hebrew word *taḥash*, which is translated "Badger" in Exod. 26, 14, indicates an animal of which the skin was employed for the outer roof of the tabernacle, ark, etc. It seems to be equivalent to the Arabic *tuchash*, which denotes the Porpoises, Dolphins, and Dugongs of the Red Sea. The largest of these is the Red Sea Dugong (*Halicore tabernaculi*), the skin of which was almost certainly employed for the purpose indicated.* Dugongs and Manatees (which gave rise to the fable of Mermaids) are quite distinct from Whales, Porpoises, and Dolphins, representing another order—the Sirenia—of which the few living members are herbivorous.

BAT.

The Hebrew word *ʾāṭallēph*, translated in the Bible usually as "Bat" (Lev. 11, 19), but in one case occurring among the list of unclean Birds, certainly indicates the former animal; the ancients regarding Bats as akin to Birds. Among the common members of the group in Palestine is the Syrian Tomb-Bat (*Taphozous nudiventris*); but an allied Egyptian species is shown in the wall-case on the left side of the bay.

EAGLE. OSPREY.

The Hebrew *nésher* (coming from a root meaning to tear with the beak) is translated "Eagle," but seems to be the equivalent of the

* Mr. S. M. Perlmann has suggested (*Zoologist*, ser. 4, vol. xii., p. 256, 1908) that the Okapi is the animal indicated by *taḥash*.

Arabic *nissr*, the name of the Griffon Vulture (*Gyps fulvus*), and thus indicates that bird. "Vulture" would in many passages of the Old Testament suit the context much better than "Eagle"; and the same is the case with regard to *aētos*, which in the New Testament is translated "Eagle." *Nisroch*, the Vulture-god of the Assyrian sculptures, is a deification of the Griffon Vulture.

"Osprey" may indicate not only the bird (*Pandion haliaëtus*) properly so called, but likewise others of the smaller members of the Eagle group, such as the Short-toed Eagle (*Circaëtus gallicus*), which is not uncommon in Palestine.

VULTURE. KITE. GLEDE. HAWK.

Dayyâh and *ayyâh* are both translated in some cases as "Vulture," although the former is the equivalent of *k'dayah*, the Arabic name of the Black Kite (*Milvus ater* or *M. korschun*), while the latter probably indicates the typical or Red Kite (*M. ictinus*), and is in certain instances thus rendered in the Bible. "Glede" (Deut. 14, 13), an old name for the Kite, is the translation of the Hebrew *rââh*, which may indicate the Buzzard (*Buteo vulgaris*). "Hawk" (Job 39, 26), the translation of the Hebrew *nêç*, probably indicates several of the smaller Birds-of-prey, such as the Kestrel (*Falco* [or *Cerchneis*] *tinnunculus*), Hobby (*F. subbuteo*), etc.

"GIER-EAGLE."

This translation of the Hebrew *râhâm* (Lev. 11, 18) really indicates the black and white Egyptian Scavenger-Vulture, or "Pharaoh's Hen" (*Neophron percnopterus*), which is common throughout the East, where it is of great value in sanitation. Its Arabic title is *racham* or *rachma*.

"NIGHT-HAWK." OWL.

In rendering the Hebrew *tahmâs* as "Night-Hawk" (Lev. 11, 16) the translators probably had in mind the Night-jar (*Caprimulgus europæus*), but the word apparently signifies a Bird-of-prey, and may be intended for the Barn Owl (*Strix flammea*), or some other kind of Owl. "Owl," or "Little Owl" (Lev. 11, 17), is probably the correct translation of *kôs*, and may refer to the species known as the Southern Little Owl (*Athene glaux*). *Qippôz*, rendered the "Great

Owl" (Isa. 34, 15), indicates another member of the group that cannot be definitely identified. On the other hand, *yanshûph*, which is also rendered "Owl" (Isa. 34, 11), apparently indicates the Sacred Ibis (*Ibis religiosa*). In certain passages "Owl" appears to stand for Ostrich (*q.v.*).

PELICAN. CORMORANT.

The Hebrew word *qââth*, coming from a root meaning to vomit or disgorge, is rightly translated "Pelican" (Psalm 102, 6), the name referring to the manner in which those birds feed their young by disgorging fish. Two species, *Pelecanus onocrotalus* and *P. crispus*, occur in Syria, the latter distinguished by curled feathers on the head. In the expression, "Pelican of the wilderness," the final word refers to any kind of uninhabited place, just as in India "jungle" may denote a desert. *Shâlâkh* is also translated "Cormorant" (Lev. 11, 17), as is likewise *qââth* (Isa. 34, 11; Zeph. 2, 14); in the former instance the rendering may be correct. Two species of Cormorants, *Phalacrocorax carbo* and *P. desmaresti*, are found in the Mediterranean.

STORK.

The Stork (*Ciconia alba*), mentioned in Jer. 8, 7, is undoubtedly the bird denoted by the Hebrew *hāsîdâh*, which means "the kind one." Storks abound during summer in all Eastern cities, where they nest on the houses, and are protected by the inhabitants on account of their value as scavengers. The Black Stork (*C. nigra*), which is also a native of Palestine, does not frequent human dwellings.

BITTERN. HERON.

The Hebrew *qippôd*, which occurs in several passages, and is translated "Bittern" (Isa. 14, 23), probably indicates that bird (*Botaurus stellaris*), which haunts marshy situations, such as may occur in the neighbourhood of ruins, and utters a loud booming cry. Whether the "Heron" of the Bible (Lev. 11, 19), the translation of the Hebrew *ânâphâh*, really indicates one or more of the members of the family *Ardeidæ*, is doubtful.

PEACOCK.

The word rendered "Peacock" in 1 Kings 10, 22, is *tukki*, which it has been suggested is equivalent to *togei*, or *tokei*, the Tamil name

of that bird. Peacocks (*Pavo cristatus*) are mentioned as having been brought to Syria from Tarshish together with apes and ivory; whence it has been assumed that Tarshish was either in India or Ceylon. It, may, however, have been a port on the east coast of Africa to which Indian products were carried. It has also been suggested by Dr. P. Haupt, in the article cited on p. 12, that Tarshish indicates the Cinnabar Mines of Spain. The "Apes" cannot be identified.

"SWAN."

The rendering of the Hebrew *tinshémeth* as "Swan" in Lev. 11, 18, is almost certainly wrong; and it has been suggested that the bird indicated by that word is really the Purple Waterhen (*Porphyrio cæruleus*), which is a common species in the Mediterranean countries. The Hebrew word almost certainly denotes a Water-Bird; and in the Septuagint it is translated *Porphuriōn*, but in another version *Ibis*.

OSTRICH.

Although for the most part otherwise translated, there is little doubt that the Hebrew words *bath-hayya'ânâh*, *yâ'ên*, and *rēnânim* (?) indicate the Ostrich (*Struthio camelus*), the range of which extends from Barbary to Syria, Arabia, and even Mesopotamia, although it does not now include Egypt. The Ostrich is mentioned in Lam. 4, 3; but the Ostrich of Job 39, 13, is the rendering of the Hebrew *nôçâh* (i.e. feathers).

PARTRIDGE. QUAIL.

Two kinds of Partridge, the red-legged Chukar Partridge (*Caccabis chukar*) and Hey's Sisi Partridge (*Ammoperdix heyi*), abound in Syria, and both may be indicated by the Hebrew *qôrê*, which signifies "the caller," and is translated "Partridge" (Jer. 17, 11; 1 Sam. 26, 20). This word, like the Hindustani *chukar*, is derived from the bird's note.

Sēlâw, the Hebrew equivalent of *salwâ*, the Arabic name of the Quail (*Coturnix communis*), is rightly taken to indicate that bird.

TURTLE. TURTLE-DOVE. DOVE.

The Hebrew name *tôr*, like the English "Turtle," is derived from the coo of the Turtle-Dove (*Turtur communis*), a species that, together with the Palm-Dove (*T. senegalensis*), visits Palestine in

large flocks every summer. The word is rightly translated "Turtle-Dove" in Gen. 15, 9, and Lev. 1, 14.

The "Dove" of Scripture (Isa. 38, 14), the rendering of the Hebrew *yônáh*, is the Rock-Dove, or Blue Rock-Pigeon (*Columba livia*), the parent-stock of the numerous domesticated breeds of Pigeons.

CRANE. SWALLOW.

In the two passages, "Like a Crane or a Swallow, so did I chatter" (Isa. 38, 14), and "The Crane and the Swallow observe the time of their coming" (Jer. 8, 7), the translators have practically identified the two species intended, but have rendered *sûs* or *sîs*, which properly indicates the Swift (*Cypselus apus*), and is equivalent to the Arabic *sûs*, as "Crane," while '*âgûr*, which really means the Crane, is translated "Swallow."

The word *děror* is probably rightly translated "Swallow" (*Hirundo rustica*), although it may also include other birds of rapid flight.

"LAPWING."

The Hebrew *dûkîphath*, rendered "Lapwing" in the Authorised Version (Lev. 11, 19), probably indicates the Hoopoe (*Upupa epops*), as it is very similar to the Coptic and Syriac names of that bird, which abounds in Palestine.

SPARROW.

In our version the Hebrew *šippôr*, signifying to chirp or twitter, and the Greek *strouthion* are rendered "Sparrow," and may refer to any of the smaller perching birds, many of which are now, as formerly, used for food in Syria. The "Sparrow alone upon the house top," referred to in Psalm 102, 7, is, however, very probably the Blue Rock-Thrush (*Monticola cyaneus*), which is habitually a solitary species.

RAVEN.

The Hebrew '*ôrêbh* must be taken in a wide sense, so as to include not only the Raven (*Corvus corax*), but likewise the Crow (*C. corone*), Rook (*C. frugilegus*), and other members of the same group. The Raven of Prov. 30, 17, is the correct rendering of '*ôrêbh*; but it has been suggested that the Ravens, '*ôrêbhîm*, that fed Elijah (1 Kings 17, 6) were the people of Orbo, a small town near the Cherith Valley.

CHAMÆLEON. LIZARD.

The translation of the Hebrew *kôah* as "Chameleon" in Lev. 11, 30, appears incorrect; and it has been suggested that one of the large Lizards known as "Monitors," such as the Egyptian *Varanus niloticus* or *V. griseus*, is the animal referred to. On the other hand, the word *tinshémeth*, in the same passage, which is translated "Mole," may indicate the Chamæleon (*see* MOLE, p. 11). The reason

FIG. 6.



THE CHAMÆLEON.

(From "The Cambridge Natural History.")

for the latter opinion is that *tinshémeth* comes from a root meaning to breathe, thus suggesting the Chamæleon, which was believed to live by swallowing air. "Lizard," the translation of the Hebrew *lētááh*, cannot be identified with any particular species, although it doubtless indicates Lizard-like Reptiles.

"TORTOISE."

The Hebrew word *ṣáb*, translated "Tortoise" in the Authorised Version (Lev. 11, 29), but amended to "Great Lizard" in the Revised

Version, which occurs only in Lev. 11, 29, appears to be the equivalent of *dab*, the Arabic name of the Spiny-tailed Lizards of the genus *Uromastix*. These Lizards, of which *U. spinipes* is the typical species, grow to a length of about 2 feet, and are common in the desert districts of Syria, Arabia, and N. Africa, as well as India, where they live in holes. They take their name from the rings of stout spines girdling the tail.

SNAIL.

Of two words rendered "Snail" in our Bible, the translation is probably correct in the case of *shablûl* (Psalm 58, 8); the slimy track of Snails probably giving rise to the idea that the body is wasting. *Hômêl* (Lev. 11, 30), on the other hand, which appears related to the Arabic *chometan* (i.e. sand), may indicate desert Lizards of the Skink group, such as *Scincus officinalis*.

SERPENT. ASP. ADDER. COCKATRICE.

The ancient Hebrews were probably acquainted with about half-a-dozen kinds of poisonous Serpents, for which they had several names. *Pêthen*, rendered "Asp" (Isa. 11, 8), was a species used by snake-charmers, and probably therefore the Egyptian Cobra (*Naja haje*), which ranges into Syria. "Adder" (Psalm 58, 4), or sometimes "Cockatrice" (Isa. 11, 8), stands for any Snake of the Viper group, and is used for several Hebrew words. Of these, *shēphiphôn* probably indicates either Cleopatra's Asp (*Cerastes vipera*) or the Horned Viper (*C. cornutus*), while 'akhshûbh may be the Sand-Viper (*Echis carinatus*). "Fiery flying serpent" (Isa. 14, 29) is apparently a mythical expression; but the "fiery serpent" (Numb. 21, 6) may possibly have been the very large Guinea-worm (*Dranunculus medinensis*).

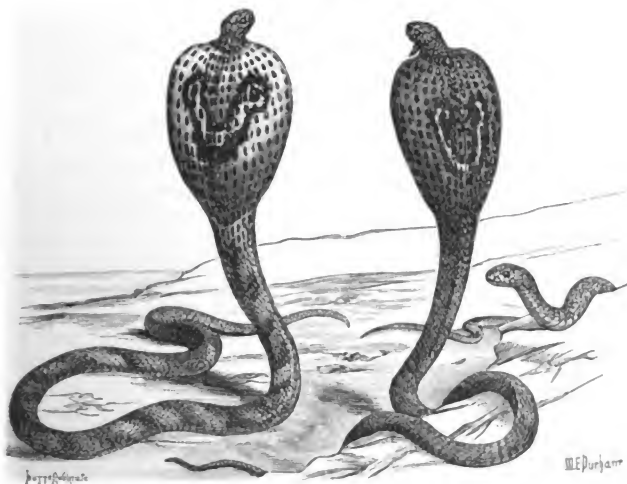
FROG.

The word "Frog," which is at least an approximately correct translation, occurs several times in the Old (e.g., Exod. 8, 2) and once in the New Testament (Rev. 16, 13). Tristram stated that the only species inhabiting Egypt is the Edible Frog (*Rana esculenta*) of Europe, Asia, and North Africa; but that species is rare in Egypt, where the ordinary Frog is *Rana mascariensis* of Africa. This may have been the Frog of the Plagues; but there is a possibility that Toads constituted the visitation, some support to this being afforded by the fact that *Bufo regularis* makes its appearance in Egypt at certain seasons, or after rain, in numbers.

BEE. HONEY. HORNET.

Palestine, like India, abounds with Bees of various kinds, which often dwell in immense swarms, and are thus dangerous to travellers. The Palestine Honey-Bee (*Apis fasciata*) is nearly allied to the European species. In Hebrew the Bee is called *dēbōrah* and honey *debash*; the latter word also indicating a decoction of grape-juice. The translation of the Hebrew *qir'ah* as "Hornet" is correct.

FIG. 7.



THE INDIAN COBRA, A SPECIES ALLIED TO THE AFRICAN COBRA.
(From "The Cambridge Natural History.")

LOCUST. GRASSHOPPER. CANKERWORM.
CATERPILLAR. BEETLE.

Several Hebrew words are rendered "Locust" and "Grasshopper" (Lev. 11, 22) in the Bible; but it is probable that *arbeh*, the Locust of the Plagues (Exod. 10, 4-6), indicates the North African Locust (*Acridium peregrinum*), which, like the Migratory Locust (*Pachytylus cinerascens*), ranges into Palestine. *Yéleq* and *hásil*, both of which

appear to mean "the licker-up," and are translated indifferently "Caterpillar" (Psalm 78, 46) and "Cankerworm" (Joel 1, 4), probably indicate the immature, non-flying stages of the Locust, the "voetgangers" of the Dutch in South Africa. "Beetle" (Lev. 11, 22) apparently also indicates some kind or phase of Locust; it is the rendering of the Hebrew *ḥargól*; the same is the case with "Bald Locust" (Lev. 11, 22). See also WORM.

WORM. MOTH. PALMER-WORM.

"Worm" occurs in many passages (*e.g.*, Isa. 51, 8) as the translation of the Hebrew *sās*, *rimmāh*, and *tólé'áh*. Of these, *sās*, which is found in Isaiah, denotes the larva of a species of Clothes-Moth (*Tinea pellionella*), characterised by eating cloth in such a manner as to make it appear worn; and the same is the case with *'áh*, rightly translated "Moth." *Rimmāh* and *tólé'áh* denote Caterpillars and Grubs of various Insects, and less commonly Earth-Worms. The reference in Jonah 4, 7, to a gourd being withered by the attack of a worm (*tólé'áh*) suggests the larva of a large Beetle or Moth. The passage in Job 27, 18, "He buildeth his house as a moth, and as a booth that the keeper maketh," probably refers to the large rough larval case of small twigs made by the bigger Psychid Moths. The Greek *skōlēx*, in the New Testament, translated "Worm," is equivalent to *tólé'áh*. "Palmer-Worm" (Joel 1, 4), the rendering of the Hebrew *gázám*, is almost certainly a Caterpillar, but may also include one or more of the immature stages of the Locust (*see* CANKERWORM).

SCORPION. SPIDER. ANT.

Several kinds of Scorpion are common in Palestine, especially in the deserts, and the word *'agrāb* is no doubt rightly translated (Deut. 8, 15) in this sense. Two words, *'akkābīsh* (Isa. 59, 5) and *sēmāmīth* (Pr. 30, 28), are rendered "Spider"; and in the case of the first, at any rate, the translation is correct. The second word may, however, indicate a Gecko, although it has been suggested that the movements of a running Spider may justify the application of the term "hands" to its limbs. "Ant," the rendering of the Hebrew *nēmālāh*, occurs twice in Proverbs (6, 6-8; 30, 25), and is no doubt rightly rendered. Numerous kinds of Ants, some of the genus *Formica* and others of *Myrmica*, inhabit Palestine, and differ from those of northern countries in their habit of storing up grain in the time of harvest.

FLIES. FLEAS. LICE.

Zēbūb and *ʾārōb* are both translated "Fly" or "Flies" (Exod. 8, 21-32; Psalm 78, 45; Eccles. 10, 1), the former, which is the equivalent of the Arabic *athebab*, apparently signifying some kind of biting Fly, such as a Horse, or Gad, Fly (*Tabanus*), although in some instances used in a more general sense. The serious torment that Flies constitute in the East is testified by the cult of the Phœnician idol Baalzebub, the Lord of Flies. *ʾĀrōb*, which is the term employed for the Flies of the Plagues, indicates the House-Fly (*Musca domestica*). "Flea" is mentioned twice in 1 Samuel (24, 14; 26, 20), and, like "Lice," the rendering of *kinnim* (Exod. 8, 16), is correctly translated. Lice are common among the desert Bedouin, but would be repugnant to the cleanly Egyptians of Biblical times.

HORSE-LEECH.

The word "Horseleach" occurs in Prov. 30, 15, as the translation of the Hebrew *ʾālūqāh*, which is the equivalent of the Arabic *ʾalaq*, the name of the Horse-Leech (*Hæmopsis sanguisuga*), and perhaps of other kinds of blood-sucking Leeches. The expression "two daughters" is generally considered to be figurative, and to refer to the blood-sucking habits of Leeches. The ordinary Medicinal Leech represents another genus, *Hirudo*. A specimen of the Horse-Leech is exhibited.

PURPLE DYE.

"Purple" was a colour held in high estimation among the ancients, and was obtained by using as a dye the secretion of certain Whelk-like Molluscs of the genera *Purpura* and *Murex*; the former of which takes its name from producing this dye. The dye, which is the product of a gland situated near the gills, is yellowish when first extracted, and turns purple only when exposed to sunlight. The dye was in use in Minorca at least till 1858; but even in early times became very scarce. The species most used as a source of supply was *Murex trunculus*, of which a shell, together with one of *M. brandaris*—a species also used as a source of the dye—is shown in the case. The ancient "purple" was probably more the colour of the flower of the Crown Imperial, or Giant Fritillary.

PEARLS*.

Pearls are referred to in Job 28, 18; "No mention shall be made of coral, or of pearls." In this passage the word is the translation of the Hebrew *gābīsh*, meaning ice, and the reference would therefore seem to be to rock-crystal. On the other hand, the *margaritai* of the New Testament (e.g., Matt. 13, 45) are undoubtedly true Pearls, which are largely the product of the Pearl-Oyster (*Margaritifera margaritifera*), and are secreted by those Molluscs around the larvæ of parasitic worms. A moderately large kind of Pearl-Oyster (*M. m. erythrææ*), of which a specimen is exhibited, occurs in the Red Sea, and a rather smaller kind (*M. m. persica*) in the Persian Gulf; and it was doubtless from one or both of these that Palestine obtained its pearls. The small Lingah Pearl-Oyster (*M. vulgaris*), of the Persian Gulf, is fished only for its shell.

CORAL†. SPONGE.

Coral, Hebrew *rāmōth* (meaning that which grows tall, or is tree-like), is mentioned in Job 28, 18, and in Ezek. 27, 16. The Coral of Scripture, which was brought to Tyre either from the Red Sea or the Persian Gulf, was probably the precious Red Coral (*Corallium rubrum*), of which a specimen preserved in spirit, so as to show the Polyps, is exhibited. Coral was broken off from submarine rocks and drawn up to the surface by cords; and it has been stated that in the passage in Job, the words "the price of wisdom" might be better rendered "the drawing up of wisdom," and thus refer to the coral-fishery. Coral of all kinds is the calcareous skeleton-like secretion of Polyps near akin to Sea-Anemones.

Sponge, of which several kinds are abundant in the Mediterranean, is mentioned only in the New Testament (e.g., Matt. 27, 48), as the translation of the Greek *spongos*.

MANNA.

An Insect of the genus *Coccus*, nearly allied to the Cochineal Insect (*C. cacti*), infests the leaves of Tamarisk (*Tamarix mannifera*) on Sinai, piercing them with its proboscis, and thereby causing an exudation of a sweet gummy secretion. This hardens and drops from the boughs, when it is collected by the natives, who regard it as the Manna of the Israelites (Exod. 16, 15), although, as mentioned on p. 41, this has a quite different source.

* See also p. 71.

† See also p. 70.

II.—PLANTS.

It has been estimated that 120 plants are mentioned in the Bible, but, as in the case of the animals, it is often difficult or impossible to associate the Hebrew name with a specific plant. It must also be remembered that botany as a science was in a very crude state at the date of the preparation of the Authorised Version, and the rendering adopted is often misleading from the point of view of modern terminology. In some instances the translators have not attempted to find an English equivalent for the Hebrew, as in the case of the timber of which Noah built the ark, where *gopher* is simply a transliteration of the Hebrew word. In many cases they have used English words that a knowledge of the flora of Palestine shows to be inappropriate (*see*, for instance, under APPLE, CHESTNUT, ROSE), and in others the same name does duty for more than one plant; oak, for instance, includes the terebinth. Some words are of a very general application, such as those indicating spiny or thorny plants, which are a characteristic feature of the drier, hotter parts of Palestine and the desert countries adjoining; or the term "bitter herbs," in reference to which Canon Tristram remarks: "There are not many of the *Cruciferae* or *Compositae* families of plants which Orientals do not employ for their varied bitter salads."

In the present exhibition a certain general arrangement has been followed. The front end of the case is occupied with specimens of useful woods so far as these can be identified. Following round to the right are trees and shrubs, finishing with the vine in the back end of the case. The left side deals with herbs, mainly food-plants—very few flowers are mentioned in the Bible—with the plants from which perfumes were derived, and finally a few of the characteristic thorns and thistles.

WOODS.

BOX-WOOD.

In the passage in Ezekiel (27, 6), "The company of the Ashurites have made thy benches of ivory," the word rendered "Ashurites" should probably be translated "Box-wood," and the passage should

read, "The benches of the rowers have they made of box-wood inlaid with ivory."

The Box-tree of Palestine, *Buxus longifolia*, is closely allied to *B. sempervirens*, the species native and commonly grown in England, a specimen of the wood of which is shown here. It is hard, close-grained, and remarkably homogeneous and durable.

OLIVE-WOOD. *See* OLIVE.

GOPHER-WOOD.

The Hebrew *gopher*, which occurs once only (Gen. 6, 14, "Make thee an ark of gopher-wood"), has been variously explained. Perhaps the most probable interpretation is that it is the same as *copher*, the Cypress (*Cupressus sempervirens*), a tree that grows in great abundance in Chaldea and Armenia, and from its toughness and close texture is well adapted for ship-building.

ALMUG OR ALGUM TREE.

Almug or Algum trees were imported from Ophir (probably India) by Hiram of Tyre for Solomon, who used the wood for pillars in the Temple and the king's house and for musical instruments (1 Kings 10, 12). It was evidently a very precious wood, and must have been hard and close-grained. It has been identified with the Red Sandal-wood, or Sanders-wood, of India, which is very heavy, fine-grained, and of a brilliant red colour, and is still used in the East for making musical instruments.

The plant referred to has been identified also with the well-known Sandal-wood (*Santalum album*) of India, a very hard, close-grained, fragrant wood, used for carving and cabinet work.

Specimens of both of these woods are shown.

EBONY.

Ebony (Hebrew, *hobnīm*) is mentioned by Ezekiel (27, 15) as a precious article brought to Tyre by the merchants of Dedan—the inhabitants of the Persian Gulf. It is the heart-wood of a tree, *Diospyros Ebenum*, a native of Southern India and Ceylon; the outer wood is white and valueless.

CEDAR-WOOD. *See* CEDAR.

A small specimen of the wood and bark in cross-section is shown ; also a fragment of a Cedar beam brought from the palace at ancient Nineveh by Layard, the Assyrian explorer.

THYINE WOOD.

Thyine wood, mentioned in Rev. 18, 12, is the wood of a small tree (*Callitris quadrivalvis*), of very slow growth, allied to the Cypress, and a native of the Atlas Mountains in North Africa. The wood, which is dark brown in colour, very heavy, close-grained, and fragrant, was much prized in the days of the Roman Empire for inlaid work, and is still used for a similar purpose in Algeria at the present day.

SHITTIM WOOD. *See* SHITTAH TREE.

TREES AND SHRUBS.

ALMOND.

The Almond (*Amygdalus communis*) is frequently mentioned in the Bible, and is one of the native fruits of Palestine. Its flowers appear before the leaves, and it is the earliest of all the trees to put forth blossom, whence its Hebrew name *shâqéd*, hasten. (Compare the play on the word in Jer. 1, 11, 12.) Aaron's rod that budded (Numb. 17, 8) yielded almonds, and almonds were among the presents taken down to Egypt by Jacob's sons. The fruit was the model for the ornaments of the candlesticks in the tabernacle. The word *lûz*, translated "Hazel" in Gen. 30, 37, is supposed to refer to the Almond.

APPLE.

The Hebrew *tappûah*, translated "Apple," occurs in the Song of Solomon (2, 3 and 5 ; 7, 8 ; 8, 5), also in Prov. 25, 11—"A word fitly spoken is like apples of gold in pictures of silver"—and elsewhere. This does not refer to our Apple, which is not native, nor does it thrive under cultivation in Palestine. The Quince and Citron have been suggested among others as the fruit indicated, but from the passages in which the tree is mentioned it is evident that it must

have supplied a grateful shade, and that the fruit must have been sweet to the taste and beautiful to see. Canon Tristram suggests the Apricot (*Armeniaca vulgaris*) as the only likely fruit that combines those characters. Though not a native of Palestine, the Apricot was early introduced from Armenia, and is now common everywhere.

BAY.

The Hebrew *ezráh* is once translated "Bay-tree" (Ps. 37, 35), and the Psalmist may possibly have intended the Sweet Bay (*Laurus nobilis*), a native of Palestine and a plant well known in our shrubberies. As the word is elsewhere translated "native," as opposed to a stranger or foreigner, it has been suggested that the term applies merely to a tree grown in its native soil, and not to any particular tree.

CHESTNUT-TREE.

The Hebrew *'armôn*, which occurs twice in the Old Testament (Gen. 30, 37; Ezek. 31, 8), is translated "Chestnut-tree" in the Authorised Version, but the Chestnut is not a native of Palestine. The Revised Version, following the Septuagint, is probably correct in its rendering "Plane-tree" (*Platanus orientalis*), which is frequent by the sides of streams. This tree is well known as planted in parks and open spaces in England.

BOX.

The Box-tree is mentioned by Isaiah (41, 19, and 60, 13) as associated with the Fir-tree and the Pine. The native Box-tree of Palestine is *Buxus longifolia*, a small evergreen tree about 20 feet high, slightly differing from the species commonly grown in England. A piece of the wood is shown in the front end of the case.

CEDAR.

The Hebrew *érez* is applied in the Bible generally to trees of the Pine family, but more frequently to the Cedar of Lebanon (*Cedrus libani*), which forms extensive forests on the Mountains of Lebanon, and is also plentiful on the Taurus range. The tree is from 50 to 80 feet in height, with numerous large horizontal branches, and is quoted as a type of grandeur and lofty stature. The wood was largely used by Solomon in the erection of the Temple and of his

own palace. Specimens of the wood are shown in the front end of the case. The Cedar-wood mentioned in Lev. 14, 4, and Numb. 19, 6, was probably derived from a fragrant species of Juniper.

FIG.

The Fig (*Ficus Carica*) is the first known tree mentioned in the Bible (Gen. 3, 7), and there are frequent references to the tree and its fruit both in the Old and New Testaments. It is a native of Palestine, and is also generally cultivated there; the land was described as "a land of wheat, and barley, and vines, and fig trees, and pomegranates" (Deut. 8, 8). It reaches a considerable size, the stem being often 3 feet thick; the wide-spreading branches bear a dense foliage of large tough palmate leaves, affording a grateful shade: "they shall sit every man under his vine and under his fig tree" (Micah 4, 4). The fruits, especially when dried, form an important article of everyday food; when dried they were pressed into cakes (Hebrew, *dēbēlāh*) (see 1 Sam. 25, 18; 30, 12).

The first ripe figs (Hebrew *bikkūrāh*) appeared in spring before the leaves expanded; the green or unripe figs were called in Aramaic *paggā*, a word found in Bethphage, literally "the house of unripe figs."

FIR-TREE.

The Hebrew *bērōsh* and *bērōth*, generally translated "Fir tree" in our version, refer probably to the Aleppo Pine (*Pinus halepensis*), a native of the mountainous parts of Palestine, and common on the Lebanon range. It is associated with cedars in respect of its noble growth (Ezek. 31, 8; Isa. 37, 24). The Fir-tree as well as the Cedar was supplied by Hiram from Lebanon for the building of Solomon's Temple. It was also used for rafters (Cant. 1, 17), for the decks of ships (Ezek. 27, 5), and for musical instruments (2 Sam. 6, 5). The tree has been very largely destroyed for fuel or timber. Some commentators believe that the tree alluded to is the Cypress (*Cupressus sempervirens*), which is extensively planted in the neighbourhood of towns, but apparently is not wild in Palestine. The Hebrew *tirzāh*, translated in our version "Cypress" (Isa. 44, 14), refers to some hard-grained wood, and may or may not be Cypress. In the Septuagint and Vulgate it is translated as equivalent to "Oak," and others render it "Holly."

The Gopher-wood from which Noah built the ark (Gen. 6, 14)

has been regarded as identical with *copher*, the Cypress, which, from its tough and close-grained wood, is well adapted for ship-building, and is abundant in Armenia (*see* GOPHER-WOOD).

HEATH.

The Hebrew '*ar'âr*, '*ârô'êr*, the Heath of the desert or wilderness (Jer. 17, 6 ; 48, 6), is a dwarf Juniper (*Juniperus macrocarpa*), closely allied to the Savin, which grows in the most barren and rocky parts of the desert. It bears dark purple berries. A branch of the plant is shown.

JUNIPER.

The Hebrew *rôthem*, translated "Juniper" in several passages, is the same as the Arabic *retem*, and refers, not to a Juniper, but to a species of Broom (*Betula retam*). It is a desert shrub, very common in the ravines, growing to a height of 10 or 12 feet, and affording a grateful shade (1 Kings 19, 4, 5). It is described as the largest and most conspicuous of all the plants of the desert. The thick roots are converted into charcoal by the Arabs ; this explains the reference (Psalm 120, 4) to "coals of juniper." Job (30, 4) speaks of outcasts from Edom using Juniper roots as food in their extremity. Rithmah, one of the camps of the Israelites in the wilderness, implies "the place of *rôthem*." Specimens of branches in flower and fruit are shown.

LOCUST-TREE.

The "husks that the swine did eat," referred to in the parable of the Prodigal Son (Luke 15, 16), were the bean-like fruits of the Locust or Carob tree (*Ceratonia Siliqua*). The tree is very common in Palestine, and forms with its dense deep green foliage a conspicuous and attractive object. It blossoms at the end of February, and pods are produced in great quantity in April and May ; the Greek name (*keratia*, little horns) refers to their horn-like shape. The pods are chiefly used for feeding cattle and horses.

MULBERRY-TREE.

The Hebrew *békâim* is thus translated in 2 Sam. 5, 23, 24. It probably refers to a species of Poplar (*Populus euphratica*) resembling the Aspen, and the characteristic trembling of the leaves is probably alluded to in the expression, "the sound of a going in

the tops of the mulberry-trees." The true Mulberry (*Morus nigra*) is mentioned in the New Testament under the name of "Sycamine" (Luke 17, 6), which see (p. 32).

MYRTLE.

The Myrtle (*Myrtus communis*), several times mentioned in the Old Testament, is an abundant plant in the south of Europe, and common on hillsides in Palestine. It no longer grows on the Mount of Olives, where its occurrence is mentioned by Nehemiah (8, 15) after the return from Babylon. It is always referred to as a favourite tree, thus: "Instead of the brier shall come up the myrtle tree" (Isa. 55, 13); "I will plant in the wilderness the cedar . . . and the myrtle" (Isa. 41, 19). The Hebrew is *hūdas*, from which is formed the name Hadassah, the Hebrew form of Esther.

OAK.

Six Hebrew words from the same root are rendered "Oak" in the Authorised Version. One of these, *élāh*, is properly the Terebinth or Teil tree (which see). The other five names, *él*, *élón*, *ilān*, *allāh*, *allón*, appear to be interchangeable; Tristram suggests that *allón* stands for the evergreen Oak, and *élón* for the deciduous sorts. The most common Oak in Palestine is an evergreen species, *Quercus pseudococcifera*, resembling in general appearance the Holm Oak (*Q. ilex*). To this species belongs the so called Abraham's Oak near Hebron, which has for several centuries taken the place of the famous terebinth that marked the site of Mamre (Gen. 18, 1). It is described as the noblest tree in southern Palestine, with a trunk 23 feet in girth, and a spreading crown covering an area 93 feet in diameter.

A picture of this oak is shown, also some acorns from it.

The Valonian Oak (*Q. Ægilops*) is deciduous, and very like our common Oak in appearance. The large acorns, which are eaten by the Arabs, are borne in very large cups densely covered with long recurving teeth. The cups are rich in tannic acid, and extensively used by tanners. *Q. Ægilops* is common in Galilee, and is also abundant across the Jordan in Bashan, where it grows to a magnificent size, and is no doubt the Oak of Bashan (Isa. 2, 13; Zech. 11, 2).

A third species, the Gall Oak (*Q. insectifera*), is a deciduous tree from 20 to 30 feet high, with leaves very white on the under face.

It is less common than the other two species, but is seen occasionally in Samaria, Galilee, and on the Lebanon range.

OLIVE.

The Olive (*Olea europæa*) is the characteristic tree of Palestine. The Promised Land was a land of olive trees, oliveyards, and oil olive (Deut. 6, 11; 8, 8; Joshua 24, 13). The tree figures prominently in the first recorded parable (Judges 9, 8), where it is invited to be king over the trees. It was used by the Prophets as a type of beauty and luxuriance (Jer. 11, 16; Hosea 14, 6). The Olives in the Garden of Gethsemane on the Mount of Olives are among the oldest in the country, and tradition takes them back to the time of Christ.

The tree grows to a height of about 20 feet, and is evergreen, with narrow bluish-green leaves, and bears numerous clusters of small whitish fragrant flowers, a large number of which fall in the spring, frequently covering the ground with a white carpet (cf. Job 15, 33). The fruit, which is produced in great abundance, is like a small plum, violet in colour when ripe; the fleshy layers contain the oil, to which reference is made as an article of food (2 Chron. 2, 10), as an unguent (Psalm 23, 5; Matt. 6, 17), and for burning (Exod. 27, 20; Matt. 25, 3). The wood is yellowish, hard, and fine-grained, and suitable for cabinet work. The fruits are gathered by beating and shaking the branches (Deut. 24, 20; Isa. 17, 6).

The Olive requires to be grafted, the fruit developed from seedlings or suckers being small and worthless; hence the contrast between the wild and good Olive (Rom. 11, 17-24).

OIL-TREE.

The Hebrew 'êç shémén, translated "Oil-tree" (Isa. 41, 19), is probably the Oleaster (*Eleagnus angustifolia*), a small tree resembling the Olive in general appearance, with narrow bluish leaves, silvery white beneath, small white fragrant flowers, and a very bitter green berry which yields an inferior oil. It has a fine hard wood, from which the two cherubim in Solomon's Temple were made (1 Kings 6, 23, where the rendering is erroneously "olive-tree"). In Neh. 8, 15, the same word is translated "pine-branches." The tree is abundant in every part of Palestine above the Jordan Valley.

PALM.

The Palm of Scripture is the Date-Palm (*Phoenix dactylifera*); Heb., *tāmār*; Gr., *phoenix*. Its intimate association with Palestine is indicated in the name Phœnicia, by which the country was known to the Greeks and Romans. It was doubtless formerly more common than at the present time, and it is probable that in ancient times the whole valley of the Jordan was stocked with Palms. Jericho was the city of Palm-trees (Deut. 34, 3), and the Palm-Gardens of Jericho were famous in the time of the Herods; but owing to neglect the trees have been completely replaced by thorn and other wild trees. The Palm was also plentiful on the Mount of Olives (Neh. 8, 15), but no longer exists there. The Palm "branches" referred to (John 12, 13) are the huge leaves that crown the tall pillar-like stem. From its grace and beauty the tree was often taken as a woman's name, *Tamar* (Gen. 38, 6; 2 Sam. 13, 1; 14, 27), and was a favourite ornament in architecture, as, e.g., in Solomon's temple (2 Chron. 3, 5; 1 Kings 6, 29-35). The fruits are produced in huge clusters, and are an important food, but there is no undisputed reference to them in the Bible, though in Cant. 7, 7, "Thy stature is like to a palm-tree, and thy breasts to clusters of grapes," "dates" has been suggested as a preferable reading for "grapes."

POMEGRANATE.

The Pomegranate (*Punica Granatum*) is a small evergreen tree or large shrub widely cultivated for its fruit in warm countries, especially in those bordering on the Mediterranean Sea. Reference to its cultivation in Egypt occurs in Numb. 20, 5, and the Promised Land was described as one of "vines, and fig trees, and pomegranates" (Deut. 8, 8; Numb. 13, 23). Its Hebrew name, *rimmôn*, was given to several towns and villages in Palestine. The fruit and the flower supplied models for ornamental carving, as on the capitals of the pillars in the Temple, and for embroidery, as on the High Priest's robe.

POPLAR.

The Hebrew *libneh* (white) occurs twice in the Old Testament, and is translated "Poplar" (Gen. 30, 37; Hosea 4, 13). The reference may be to the White Poplar (*Populus alba*), which is

common in damp places, the white down that covers the under face of the leaves justifying the application of the name.

It has also been suggested that the reference is to the Storax-tree (*Styrax officinalis*), which grows abundantly on the lower hills of Palestine and in Armenia, and has white flowers resembling those of the Orange, and pale leaves with a white down on the under face. It yields a gum, which is probably the *Stacte* referred to in Exod. 30, 34, as one of the ingredients of the holy incense; but the plants are shrubs or small trees, and hardly conform to the reference in Hosea as one of the trees under which idolatrous Israel sacrificed. The Mulberry (which see) referred to in 2 Sam. 5, 23, 24, was probably a species of Poplar, *Populus euphratica*.

SYCAMINE.

The Greek *sukaminos*, translated "Sycamine tree" (Luke 17, 6), is the Black Mulberry (*Morus nigra*), which is still known in Greece as *sukaminea*. Both White and Black Mulberry trees are common in Palestine, where they are cultivated for the leaves, which are used as food for silk-worms, and also for the fruit. The Mulberry-tree (*q.v.*) of Scripture was probably a Poplar.

SYCAMORE.

The Sycamore (Heb., *shikmím*, *shikmóth*; Gr., *sukomorea*) is a species of Fig (*Ficus Sycomorus*). The Greek name is derived from *sukon*, fig, and *moron*, mulberry, from the resemblance of the leaf to that of a Mulberry. It is a large evergreen tree with low, spreading branches, bearing the fruit on short leafless twigs on the trunk or older branches; the fruit is much smaller than that of the common Fig, and but poor eating; to render it palatable it must be cut at the top before it is quite ripe to allow the acrid juice to escape. The prophet Amos (7, 14) refers to himself as a gatherer of (literally "one who scraped or cut") Sycomore fruit. It is a common wayside tree, and, with its short trunk, easy to climb (Luke 19, 4). It is very susceptible of cold, and occurs in Palestine in the mild climate of the maritime plains and in the hot Jordan Valley. The last-named locality is referred to (1 Kings 10, 27; 2 Chron. 1, 15; 9, 27) where it is stated that Solomon made cedars to be "as the sycomore trees that are in the low plains in abundance." Its wood is very light and porous, but of great durability, and was used by the Egyptians for making their mummy cases and for articles of furniture.

SHITTAH TREE. SHITTIM WOOD.

The tree itself is mentioned once only (Isa. 41, 19), but its wood is repeatedly referred to as the principal timber used in the construction of the Tabernacle in the wilderness (Exod. 25, 26, 27, 30). It is a species of *Acacia*, *A. Seyal*, a gnarled and thorny tree which flourishes in the driest situations in the Arabian desert. The timber is hard, close-grained, and of a fine orange-brown colour. It is of great commercial value as yielding gum arabic, which exudes from the bark. Several places were named from the *Acacia*, as "the Valley of Shittim" (Joel 3, 18), and the plains of Shittim—the last camping place of the children of Israel before crossing the Jordan (Numb. 25, 1).

TEREBINTH OR TEIL TREE.

The Hebrew *élâh*, denoting a strong, hardy tree, occurs in several places in the Bible, and is variously rendered "Teil tree" (Isa. 6, 13), "Elm" (Hosea 4, 13), "Oak" (Gen. 35, 4; Judges 6, 11; 2 Sam. 18, 9, 10): in Gen. 18, 1, the plural *élôn* is translated "plains." The Septuagint rightly renders it "Terebinth tree" (*Pistacia Terebinthus*), known in the Greek islands as the "Turpentine tree," from the quantity of turpentine which exudes on tapping the trunk. In general appearance it resembles the Oak, especially when it sheds its leaves at the beginning of winter. It is very common in the southern and eastern parts of Palestine, occurring generally in places too warm or dry for the Oak.

WILLOW.

The two Hebrew words *'arâbîm* and *çaphçâphâh* are rendered "Willow," indicating trees that flourished by water-courses. Several species of Willow (*Salix*) occur in Palestine, including the Weeping Willow (*Salix babylonica*), which has been associated with the tree of the Captivity (Psalm 137, 2). The Arabic *safsaf*, one of the vernacular names for Willow, is no doubt identical with the second Hebrew name mentioned.

Canon Tristram suggests that the Willow by the water-courses, of Scripture, is applicable rather to the Oleander (*Nerium Oleander*), a very characteristic plant of Palestine, forming a fringe along the whole Upper Jordan, and marking the course of streams by a line of deep green, or in the flowering season, burning red. It is a shrub with long, narrow, willow-like leaves, but sometimes attains tree-like proportions.

NUTS.

The Hebrew *ēgôz*, rendered "nuts" in Cant. 6, 11, "I went down into the garden of nuts to see the fruits of the valley," refers to the Walnut-tree (Arabic, *ghaus*). The Walnut (*Juglans regia*), a native of Persia, was early spread through Western Asia and Europe. It is cultivated everywhere in Palestine, and its grateful shade, noble spreading growth, and the fragrance of the leaves must have rendered it a favourite tree in the gardens of Solomon.

The Hebrew *botnim*, also translated "nuts" (Gen. 43, 11), refers, doubtless, to the Pistachio nut (Arabic, *batam*), the product of *Pistacia vera*, a tree allied to the Terebinth, which at a distance it closely resembles. It bears a large crop of nuts shaped like an almond, but rounder and glossy; the edible kernel is bright green, with the flavour of a walnut. It is widely cultivated in Palestine for the sake of its fruits, and as it was not found in Egypt the fruit was an appropriate present, together with the balm, honey, etc., sent by Jacob to his son Joseph.

VINE.

Frequent reference is made in the Bible to the Vine, its fruit, and the wine made from it. The plant, which is probably a native of some part of Western Asia, has been cultivated from the earliest times. Noah is recorded as planting a vineyard after the Deluge, and as making wine from the grapes (Gen. 9, 20, 21). Reference to its cultivation in Egypt occurs in Gen. 40, 9-11, and there are many representations of the plant on the Egyptian and Assyrian monuments (a photograph of one of the latter is shown). The Land of Promise was pre-eminent for its vines and the quality of the wine; and vineyards were abundant before the Israelites came into possession. The spies sent by Moses brought back a huge bunch of grapes from the vale of Eschol (*i.e.*, "cluster of grapes"); and this valley, a little to the south of Hebron, still produces the finest grapes in Palestine. The climate of Palestine is admirably suited to the Vine, and the land was once clad on every hill with terraced vineyards, traces of which are left in the wine presses and vats hewn in the rocks; but the cultivation has diminished, partly from the desolation of the land and partly from wine being prohibited to the Moslems. The latter, however, still plant the Vine for the sake of its fruit, and for raisins. References to raisins, or grapes dried in the sun, as articles of food, occur in the Old Testament (1 Sam. 25, 18; 30, 12;

1 Chron. 12, 40). Various qualities both of vines and wine are referred to in Scripture. The thin sour wine used by the poorer classes is often translated "vinegar" (Ruth 2, 14), and such was probably the vinegar offered to Christ on the Cross. "Wine on the lees" (Isa. 25, 6) was wine kept on the lees or dregs without straining, for the purpose of increasing its body. The juice was expressed by treading; it was hard work, and the men encouraged one another by shouting (Jer. 25, 30); their feet and legs were bare, but as they leaped upon the grapes their clothes became dyed with the juice (see Gen. 49, 11; Isa. 63, 2, 3).

The Wild Vine bears a small black grape which is very acid and astringent, and used only for verjuice or vinegar (Isa. 5, 2).

WILD GOURD.

The Wild Gourds (Heb., *paqqû'ôth*) that were shred into the pot of pottage (2 Kings 4, 38-40) are described as the fruit of a wild vine, and were probably the fruit of the Colocynth (*Citrullus Colocynthis*), a member of the Cucumber family with vine-shaped leaves and tendrils. The fruit is tempting in appearance, but has an extremely nauseous bitter pulp, which dries rapidly when ripe, and is used medicinally as an active purgative. It grows abundantly on the barren sands near Gilgal, and all round the Dead Sea.

An alternative suggestion is the Squirting Cucumber (*Ecballium Elaterium*), the fruit of which bursts when ripe, expelling the seeds, and also affords a drastic purgative.

Canon Tristram suggests that the Vine of Sodom (Deut. 32, 32) also refers to the Colocynth.

HERBACEOUS PLANTS.

CORN.

There are many distinct words in Hebrew relating to corn generally, such as *dâgân*, in such expressions as "corn and wine" *qâmâh*, standing corn (as in Judges 15, 5); *bar*, clean winnowed corn (Gen. 41, 49); *shibbôleth*, an ear of corn (Gen. 41, 5; Ruth 2, 2). The cereals referred to in the Bible are Wheat, Spelt (translated "Rie" and "Fitches"), Barley, and Millet.

WHEAT.

Wheat has been cultivated from prehistoric times, and is not known in the wild state. It was one of the blessings of the Promised Land (Deut. 8, 8), and the time of wheat harvest is named repeatedly (Gen. 30, 14; 1 Sam. 12, 17) as one of the epochs of the year; it was usually in May, about a month after barley harvest. There are numerous varieties of wheat; the reference in Pharaoh's dream (Gen. 41, 5) to the seven ears on one stalk appears to be to the form which is still commonly cultivated in Egypt, and known as "Mummy Wheat" (*Triticum compositum*). The form now most generally grown in Palestine is Spelt (*Triticum Spelta*), mention of which occurs in the Old Testament as the Hebrew *kussémeth*, translated "rie" (Exod. 9, 32; Isa. 28, 25) and "fitches" (Ezek. 4, 9). The wheat is sown in November or December, immediately after the barley. When reaped it is threshed, either by oxen treading out the corn on the hard threshing-floor (*cf.* Deut. 25, 4), or by a heavy wooden wheel or roller, or by a flail (*cf.* Isa. 28, 27). From the time of Solomon, Palestine was a corn-exporting country (1 Kings 5, 11; 2 Chron. 2, 10, 15). Parched corn, which is repeatedly mentioned in Scripture, was wheat scorched, generally while fresh, and was eaten without further preparation.

BARLEY.

Barley is generally grown in Palestine. It will thrive in a much lighter soil than wheat, and arrives earlier at maturity. It is usually sown about the same time as wheat, but the barley harvest is over three weeks or a month before wheat harvest begins; the barley was generally got in at the time of the Passover. The barley being in the ear was destroyed in Egypt by the plague of hail, while the wheat escaped, for it was not grown up (Exod. 9, 31, 32). Barley is the universal food in Palestine of horses and asses, and sometimes also of draught oxen; it is also largely used as food for man, but is held in much less esteem than wheat.

MILLET.

Millet (Heb., *dôhan*) is one of the ingredients from which Ezekiel was ordered to make bread: "Take thou also unto thee wheat, and barley, and beans, and lentiles, and millet, and fitches [margin, spelt], and . . . make thee bread thereof" (Ezek. 4, 9).

The two specimens shown, *Panicum miliaceum* and *Sorghum vulgare* (the North Africa Dourrha), may both be included here, as both are cultivated in the Holy Land, and the meal that they yield is used for food.

TARES.

The Tares (Gr., *zizania*) of the Parable of the Wheat and the Tares (Matt. 13, 24-30) are the Darnel (*Lolium temulentum*), a grass that is abundant in the countries around the Mediterranean Sea, and is peculiar in that its seeds are poisonous. It is a common weed in the cornfields, and in early stages would be indistinguishable from the wheat.

LENTILS.

Lentils (Heb., *'ādāshim*) are the seeds of a vetch-like plant that is much cultivated on the poorer soils in Palestine. The red pottage for which Esau sold his birthright was of lentils (Gen. 25, 29-34). Lentils, beans, and parched pulse were among the supplies brought to David in Gilead when he fled from Absalom (2 Sam. 17, 28). It is generally used as a pottage, but is also mixed with wheat, barley, beans, etc., for bread (cf. Ezek. 4, 9).

REED.

The Reed of Egypt and Palestine is *Arundo Donax*, the slender yielding stem of which reaches 12 feet in height, and bears at the top a magnificent cluster of blossom. It is doubtless the "reed shaken with the wind" of the wilderness (Matt. 11, 7).

BULRUSH. RUSH.

The Hebrew *gómě*, translated "bulrush" (as in Exod. 2, 3) and "rush" (as in Isa. 35, 7), is without doubt the Papyrus (*Cyperus Papyrus*), which formerly abounded on the Nile, flourishing in the mire, as described in Job (8, 11), but is now wholly extinct in Egypt. The stem is 10 or more feet high, and ends in a many-rayed broom-like head of minute flowers. From the white pith, cut lengthwise into thin slices, was made the earliest known paper.

FLAX (*Linum sativum*).

The use of linen was universal in Egypt, as it was the exclusive textile fabric. The importance of the crop is indicated by its mention in the plague of hail (Exod. 9, 31), which occurred at the

time when "the flax was bollen"—i.e., forming the seed-pod. Flax was in cultivation in Canaan before the entrance of the Israelites: Joshua's spies were hidden on the roof of the house at Jericho with the stalks of flax which were spread to dry in the sun (Joshua 2, 6), as is the custom at the present day. Its use for lamp-wicks is referred to in the quotation, "The smoking flax shall he not quench" (Isa. 42, 3; Matt. 12, 20).

HYSSOP.

There has been much discussion as to the identity of the plant that was used for sprinkling the door-posts with the blood of the paschal lamb (Exod. 12, 22), and also as a sprinkler in the purification of lepers and leprous houses (Lev. 14, 4, 6, 51), and in the sin-offering (Numb. 19, 6, 18). The Caper (*Capparis spinosa*) is perhaps the most likely suggestion; it is a bright green creeper, the long stems of which hang from the fissures of the rocks in the desert, and is plentiful in Egypt and the desert of Sinai. Another suggestion is *Satureia Thymbra*, a plant something like the mint; and still another, the marjoram, *Origanum vulgare*: bunches of either of these would form an efficient sprinkler.

Few references to FLOWERS occur in the Bible. The Rose and Lily are both mentioned in the English version, but it is very doubtful what specific flowers are referred to.

ROSE.

Two references to the Rose occur in Scripture: "I am the Rose of Sharon" (Cant. 2, 1), and "The desert shall rejoice and blossom as the rose" (Isa. 35, 1). The Hebrew word *hābaqéleth*, which has been translated "rose," indicates a bulbous plant, and may refer to the sweet-scented Narcissus (*Narcissus Tazetta*), a native of Palestine, and at the present day a great favourite with the inhabitants. The plant known to us as the rose is not a native of Palestine, except in the mountainous country in the north.

LILY.

The Hebrew *shōsān* and *shōsannāh*, translated "lily," occur in several passages in the Song of Solomon and elsewhere in the Old Testament. In the Sermon on the Mount the lilies of the field

(Greek, *krina*) are mentioned for their beauty. There has been much discussion as to what particular flower may have been intended. The Arabs apply the same word, *susan*, to any brilliantly flowered herb, as the tulip, anemone, or ranunculus. The true Lily is not a native of Palestine. One of the most conspicuous and wide-spread of the spring flowers is *Anemone coronaria*, which forms a brilliant carpet on the plains, and is plentiful by the shores of the Lake of Galilee. It meets all the requirements of the various allusions, and may well have been the flower indicated.

CUCUMBER. MELON.

Cucumbers and Melons are referred to in Numb. 11, 5, when the Israelites regretted the good things they had left in Egypt.

The common Cucumber (*Cucumis sativus*) is extensively grown in Egypt and Palestine, and forms an important item in the summer food of the poor. "The lodge in a garden of cucumbers" (Isa. 1, 8) was the rude booth erected to protect the field from destructive wild animals, such as jackals.

The Melon (*Cucumis Melo*) and the Water Melon (*Citrullus vulgaris*) are both largely cultivated in Palestine and Egypt.

GOURD.

The only reference occurs in Jonah (4, 6-10), and there has been much discussion as to the meaning of the Hebrew *kikayon* there used. It has been identified on etymological grounds with the Castor-oil tree (*Ricinus*), which, however, is not an arbour plant, and the original rendering is probably the correct one, as the Gourd (*Cucurbita Pepo*) is a rapidly growing climber that would quickly cover a booth and afford grateful shade. It also withers very quickly if the stem is injured.

MANDRAKE.

The fruit of the Mandrake (*Mandragora officinarum*) (Heb., *dūdāim*, love-plants) is still valued by the natives of Palestine, as it was in the time of Rachel and Leah (Gen. 30, 14). It resembles a large round yellow plum, and has a peculiar smell (see Cant. 7, 13) and a pleasant sweet taste. Many strange superstitions have been associated with the plant; it was supposed to resemble the shape of a man, and to shriek when dug up.

ONION. LEEK. GARLICK.

Mention of these occurs in one passage (Numb. 11, 5) among the good things that the Israelites had enjoyed in Egypt, and were no longer able to procure in the wilderness. Herodotus refers to the Onion (*Allium Cepa*) as an article of food in Egypt, and in its raw state it is much used by Orientals when on a journey, as a preservative against thirst.

The Leek (*Allium Porrum*) is the rendering of the Hebrew *hâçîr*, which elsewhere in the Old Testament is rendered "herbs" or "grass," doubtless rightly, as it is derived from a root signifying to be green. The grass-like leaf and green colour of the leek render the word appropriate.

Garlic (Heb., *shûm*) is another species of *Allium* (*A. sativum*), akin to the onion, and much cultivated in Egypt and Syria.

MINT. ANISE. CUMMIN. RUE.

These four herbs are referred to as subjects of tithe by the scrupulous Jews (Matt. 23, 23; Luke 11, 42).

Mint was commonly used with their meat by the Jews, and is said to be one of the bitter herbs eaten with the paschal lamb. The common wild mint of the country is *Mentha sylvestris*.

Anise or Dill (*Anethum graveolens*) is a herb resembling the Caraway in appearance, and is cultivated in the East for its seeds, which are used as a carminative and for seasoning dishes. To the same family (Umbelliferae) belongs Cummin (*Cuminum sativum*), also cultivated for its seeds, which are often used as a spice in the East. Isaiah alludes to the mode in which the seeds are beaten out (28, 27).

Rue (*Ruta graveolens*), a herb with a powerful distinctive odour, was highly prized by the ancients for its medicinal properties, and was long regarded as efficacious in warding off contagion.

FITCHES.

Two words are translated "fitches" in the Authorised Version. One, the Hebrew *kussémeth* (Ezek. 4, 9), is elsewhere translated "rie" (see WHEAT). The other is the Hebrew *qéçah*—"the fitches are beaten out with a staff" (Isa. 28, 27). This refers to a small annual, *Nigella sativa*, closely allied to the plant known in gardens as Love-in-a-mist; it is cultivated in Egypt and Syria for its black seeds, which are used as a condiment.

MANNA.

A species of Lichen (*Lecanora esculenta*), found in North Africa and Eastern deserts and mountains, supplies the inhabitants with food that they regard as sent from heaven. Great quantities are sometimes carried by the wind into the valleys, where it is then collected; it forms small greyish or whitish lumps from the size of a pea to that of a hazel-nut.

The sweet substance now known as Manna is an exudation from the bark of the Manna Ash (*Fraxinus Ornus*); a similar exudation occurs on other trees, including the Tamarisk, which grows in the Sinai peninsula, but it is collected only in small quantities.

A Lichen (*Roccella tinctoria*) has also been suggested as one of the sources of the blue or purple dyes referred to in Scripture. It has long been used in the East for this purpose.

MUSTARD.

The small size of the Mustard seed—"a grain of mustard seed"—is used by Christ as an example on three occasions; in one case also it is compared with the size of the plant when grown—"the greatest among herbs," becoming "a tree" (Matt. 13, 31, 32). The Common Mustard of Palestine is the same species as our own mustard, *Sinapis nigra*, but grows to a much greater size in Palestine, especially in the richer soils of the Jordan Valley; plants as tall as a horse and its rider are mentioned by travellers.

WORMWOOD.

Wormwood (Heb., *la'ānāh*) is frequently used metaphorically as something bitter. It is the common name of plants of the genus *Artemisia*, well known for their bitter taste. Several species grow in Palestine; the one shown, *Artemisia monosperma*, occurs along the coast.

PERFUMES.

Many of the perfumes mentioned in the Bible are derived from plants that were not native of Palestine. The product was imported, as in the case of Spikenard or Aloes from Northern India, or Frankincense and Myrrh from Arabia.

SPIKENARD.

Spikenard is procured from a Himalayan plant, *Nardostachys jatamansi*, the young spike-like shoots of which are picked and dried. It was known in Palestine in Old Testament times (*see* Cant. 1, 12; 4, 13, 14), and in the New Testament is referred to as an ingredient of the costly ointment used by Mary to anoint the feet of Jesus (John 12, 3).

ALOES.

The Aloes mentioned in various passages in connection with other foreign spices—"myrrh, and aloes, and cassia" (Psalm 45, 8), "a mixture of myrrh and aloes" (John 19, 39)—is probably the product of a Northern Indian tree, *Aquilaria Agallochum*, from the wood of which is extracted a sweet-scented resin.

This is quite distinct from the resin known as Bitter Aloes—the product of a species of Aloe. It has, however, been suggested that the latter is the substance referred to, which was used, not for the sake of its own scent, but for retaining the scent of the other ingredients.

FRANKINCENSE.

Frankincense is a fragrant gum-resin (*olibanum*) which exudes as a milky juice from the stem and also the leaves and flowers of a small tree, *Boswellia Carteri*, the Frankincense or Luban tree, a native of tropical Arabia and Somaliland. It was an essential ingredient of the incense used by the Jews, and is similarly used at the present day.

MYRRH.

Myrrh is another gum-resinous exudation, the product of a bush or small tree, *Balsamodendron Myrrha*, with short spine-like branchlets. The gum oozes from the bark as a viscid white liquid, which rapidly hardens on exposure to air. The tree is a native of Southern Arabia and Somaliland. Frequent mention of Myrrh occurs both in the Old and in the New Testaments. It was an important ingredient of the holy anointing oil of the Tabernacle (Exod. 30, 23), and was used also as a perfume (Psalm 45, 8; Prov. 7, 17), and for embalming (John 19, 39).

BALM.

The most precious Balm, that of Gilead, was probably derived from *Balsamodendron gileadense*, a shrub or small tree, native of

Arabia and the opposite coast of Africa. It was formerly cultivated in the plains of Jericho, where it was planted, according to Jewish tradition, by Solomon, who received a root from the Queen of Sheba. The word, which is a translation of the Hebrew *çëri*, was perhaps applied to medicinal gum or oil prepared from trees of different species.

CINNAMON. CASSIA.

Cinnamon (Heb., *qinnámôn*) was one of the principal ingredients of the precious ointment of the Tabernacle (Exod. 30, 23), and is also referred to as a perfume (Prov. 7, 17 ; Cant. 4, 14). It is derived from the bark of a tree native in Ceylon and known as *Cinnamomum zeylanicum*. Cassia, which was another ingredient of the holy ointment, is similarly derived from a closely allied species, *Cinnamomum Cassia*, a native of India and China.

SAFFRON.

Saffron, which is once referred to (Cant. 4, 14) in connection with spikenard, is of high repute as a perfume and condiment in the East. It consists of the orange-red stigmas of a species of Crocus (*C. sativus*), which are dried in the sun and pounded, or pressed into small cakes.

PRICKLY PLANTS.

BRAMBLE. BRIER. THISTLE. THORNS.

At least eighteen Hebrew words are used in the Bible for prickly plants. These are indifferently rendered "bramble," "brier," "thorn," or "thistle," and there is very little to help towards their identification.

The combined heat and dryness of the climate of Palestine favour the development of thorn-bearing plants. A few of these are shown below, and an attempt has been made to associate them with the Hebrew terms of Scripture.

Âtîd, translated "bramble" in Jotham's parable of the trees (Judges 9, 14), and "thorns" (Psalm 58, 9), has been referred to *Lycium europæum*, a plant with numerous erect branches and stiff

sharp spines which is very common in all parts of Palestine, and is often used for hedges.

Dardar, translated "thistles" (Gen. 3, 18; Hosea 10, 8), is rendered *tribolos* in the Septuagint; and the same word occurs in the New Testament—"Do men gather . . . figs of thistles?" (Matt. 7, 16), and in Heb. 6, 8, where it is translated "briers." The plant referred to is generally admitted to be the Star-Thistle, *Centaurea Calcitrapa*, a troublesome weed in cornfields in Southern Europe and Western Asia.

The Hebrew *hóah* is also often rendered "thistles" (2 Kings 14, 9; Job 31, 40); also "thorns"—*e.g.*, "as the lily among thorns" (Cant. 2, 2). Two common thistles in the cornfields are *Notobasis syriaca* and *Scolymus maculata*.

A species of *Zizyphus* (*Z. spina-Christi*), a bush or tree with flexible branches bearing long sharp thorns, is supposed to have supplied the material for the crown of thorns (Matt. 27, 29). It is called *nubk* by the Arabs, and is often used as material for fences. The thorns of the wilderness with which Gideon "taught the men of Succoth" (Judges 8, 7, 16) may have referred to this tree, which is very plentiful in the Jordan Valley.

A characteristic spine-bearing plant of Palestine is a species of *Acanthus* (*A. syriacus*); the margin of the leaves bears stiff spines, and the thick flower-spike is also remarkably spiny.

III.—MINERALS.

WHEREAS a knowledge of the animals and plants now found in Palestine is of great help to us in the recognition of the animals and plants mentioned under Hebrew or Greek names in the Bible, a knowledge of the minerals now found in that country is comparatively useless for a similar purpose, since the minerals mentioned in the Bible are mostly precious stones, which, presumably, had been carried into Palestine from other lands.

There are definite references in the Bible to mineral-bearing regions outside Palestine; for instance, the "land of Havilah, where there is gold; and the gold of that land is good: there is bdellium and the onyx stone" (Gen. 2, 11, 12), the "gold of Parvaim" (2 Chron. 3, 6), the "gold of Ophir" (Job 28, 16), and the "topaz of Ethiopia" (Job 28, 19). The precious stones that were mounted in the Breastplate of the High Priest may have been acquired by the Israelites in Egypt, and have been taken thither as merchandise by travellers from distant countries.

In the time of the prophet Ezekiel (about B.C. 600), Tyre, the famed city of the Phœnicians, the greatest sea-faring traders of ancient days, was a centre of distribution of the produce of many lands: "And say unto Tyrus, O thou that art situate at the entry of the sea, which art a merchant of the people for many isles" (Ezek. 27, 3). That part of the merchandise sold at Tyre was of a mineral character is shown by the following passages from the same chapter:—

"Tarshish was thy merchant by reason of the multitude of all kind of riches; with *silver, iron, tin, and lead*, they traded in thy fairs. Javan, Tubal, and Meshech, they were thy merchants: they traded the persons of men and vessels of *brass* in thy market. . . . Syria was thy merchant by reason of the multitude of the wares of thy making: they occupied in thy fairs with *emeralds, purple, and brodered work, and fine linen, and coral, and agate*. . . . Dan also and Javan going to and fro occupied in thy fairs: bright *iron, cassia, and calamus*, were in thy market. . . . The merchants of Sheba and Raamah, they were thy merchants: they occupied in thy fairs with chief of all spices, and with *all precious stones, and gold*."

Great difficulty is found in translating the Hebrew and Greek

names of minerals mentioned in the Bible into names that would be used for the same minerals in a particular country at the present day. For it is only within the last century, through the development of the sciences of chemistry and crystallography, that it has become possible to define mineral species with any considerable approach to precision. For the differentiation of minerals in ancient Greek and Roman times stress could be laid only on density, or on characters less capable of precise determination and statement, such as colour, transparency, hardness, tenacity, fusibility, combustibility, action on other materials, and so on. Hence, various minerals were then brought together into a single kind, and indicated by a single name, that are now distributed into different kinds and mentioned under different names. For example, the Latin term *carbunculus* included in Roman times hard, transparent, red stones which would now be assigned to different species and given different names, as Oriental ruby (corundum), Balas ruby (spinel), Almandine and Pyrope (garnet); for they are entirely different from one another in characters more important than either transparency or colour from a classificatory point of view. And conversely, some minerals then distributed into different kinds and mentioned under different names are now included in a single kind and designated by a single name; for, though differing in some obvious character—for instance, colour—they are identical in percentage chemical composition and in crystalline form.

1. THE FOUNDATIONS OF THE NEW JERUSALEM.

For reasons that will become manifest later, it will diminish the risk of confusion if we consider first the minerals mentioned in the New Testament, more especially the remarkable list of precious stones given in Rev. 21, 19, 20, Authorised Version :—

“And the foundations of the wall of the city were garnished with all manner of precious stones. The first foundation was jasper (Greek, *iaspis*); the second, sapphire (Greek, *sappheiros*); the third, a chalcedony (Greek, *chalkēdōn*); the fourth, an emerald (Greek, *smaragdōs*); the fifth, sardonyx (Greek, *sardonux*); the sixth, sardius (Greek, *sardion*); the seventh, chrysolite (Greek, *chrusolithos*); the eighth, beryl (Greek, *bērullion*); the ninth, a topaz (Greek, *topazion*); the tenth, a chrysoprasus (Greek, *chrusoprasos*); the eleventh, a jacinth (Greek, *huakinthos*); the twelfth, an amethyst (Greek, *amethustos*).”

Only four of these stones are mentioned elsewhere in the New Testament, also in the Book of Revelation, namely : jasper (Rev. 4, 3 ; 21, 18), emerald (Rev. 4, 3), sardine stone (Rev. 4, 3), jacinth (Rev. 9, 17).

It will be remarked, in the first place, that the English names used in the Authorised Version for the above stones are mere adaptations of the original Greek names ; the original names, though given an English form, are really little changed. But it will be found on investigation that some of these English names, though mere adaptations of the Greek (through the Latin), are now used to designate stones quite different from those formerly designated by the Greek names from which they have been derived. For instance, according to Pliny, the *topazion* of New Testament times was a green stone yielding to the action of a file, and said to be brought from an island in the Red Sea, off the coast of Arabia. On the other hand, the topaz of the present day is not a green stone, does not yield to the action of a file, and is not brought from an island in the Red Sea. The account given by Pliny with respect to the *topazion* of his day is thus not appropriate to the topaz of our day ; it is appropriate to another kind of stone, the one now named peridot.

For the purpose of interpretation of the Bible, it is thus necessary to ascertain, not to what stones the English names in the Book of Revelation are applied now or were applied at the epoch of the authorised translation (A.D. 1611), but to what stones the Greek names were applied at the time when the Book was written.

St. John, the writer of the Book of Revelation, lived for some time in exile at Patmos, an island in the Ægean Sea, and died about A.D. 100 at Ephesus, capital of Ionia, in Asia Minor. He is thought by some to have committed the book to writing about A.D. 68-70 ; by others the writing is assigned to the close of Domitian's reign, about thirty years later. The character of the Greek itself has been described as rugged, and as suggesting that St. John, though writing in that language, thought really in Hebrew. St. John was thus a contemporary of Pliny the Naturalist, who was born in A.D. 23 and perished in A.D. 79 near Vesuvius during the great eruption that destroyed Herculaneum and Pompeii. Pliny's great work on Natural History, published in A.D. 77, only two years before his death, tells us what was known about minerals by naturalists at the time when St. John himself was living.

The following are statements made by Pliny relative to the stones mentioned by St. John as foundations of the New Jerusalem; they are arranged, for convenience of reference, in the alphabetical order of the transliterated Greek names:—

Amethystos (Latin, *amethystus*): twelfth foundation.

Four varieties were recognised as precious, all of them transparent, and of purple colour or of tints derived from purple.

One of the varieties was doubtless the amethyst of the present day.

Bērullion (Latin, *beryllus*): ninth foundation.

There were eight varieties of *beryllus*, a mineral which, according to Pliny, was already thought by some to be “of the same nature as the *smaragdus*, or at least closely analogous. India produces them, and they are rarely to be found elsewhere. The lapidaries cut all beryls of an hexagonal form; because the colour, which is deadened by a dull uniformity of surface, is heightened by the reflections resulting from the angles. If they are cut in any other way, these stones have no brilliancy whatever. The most esteemed beryls are those which in colour resemble the pure green of the sea. Some are of opinion that beryls are naturally angular.”

Probably the sea-green beryl of Pliny’s time was the sea-green beryl of the present day.

Chalkēdōn: third foundation.

Though the name *Chalcedon* (Latin form) occurs in Pliny, it is not as the name of a mineral; it is used as the name of a free town that was standing on the southern side of the Bosphorus, probably close to the site on which Scutari has since been built. Chalcedon had once been noted for its copper mines; but the latter, when Pliny wrote, had been so far exhausted that they were no longer worked. Pliny refers to a kind of *smaragdus* (a green stone) as having been found near Chalcedon, but adds that the stones were of very small size and value. They were “brittle, and of a colour far from distinctly pronounced; they resembled in their tints the feathers that are seen in the tail of the peacock or on the neck of the pigeon. More or less brilliant, too, according to the angle at which they were viewed, they presented an appearance like that of

veins and scales." In another place he refers to a stone from Chalcedon or Calchedon (another reading) as being an *iaspis* of turbid hue. It is possible that at Patmos or Ephesus, where St. John was living when he wrote the Book of Revelation, the word *chalkēdōn* was used to specify the particular kind of *smaragdus* which had been found near the town of that name. The signification now attached to the name "chalcedony" cannot be traced farther back than the fifteenth century.

In the Vulgate Version the word is Latinised as *calcedonius*.

Chrusolithos (Latin, *chrysolithus*): seventh foundation.

The *chrysolithus* was a "transparent stone, with a refugence like that of gold." Those were most valued which, "when placed by the side of gold, impart to it a sort of whitish hue, and so give it the appearance of silver."

It may perhaps have included the yellow sapphire, the yellow quartz (citrine), and the yellow jargoon (zircon) of the present day. The term "chrysolite" is now applied to a different mineral, namely, to a yellow variety of olivine, a species which includes the green mineral peridot as another of its varieties.

Chrusoprasos (Latin, *chrysoprasus*): tenth foundation.

The *chrysoprasus* was regarded by some naturalists of the time of Pliny as a variety of *beryllus*. The first variety of *beryllus* and the most esteemed was, as already stated, of a pure sea-green colour; the second was paler, and approached a golden tint; the third, allied to the second in brilliancy, but more pallid, was the *chrysoprasus*. The latter was thought by other naturalists to belong to an independent genus of stone. In another place Pliny describes the colour as like that of the leek, but as varying in tint between the green *topazion* of his day (our peridot) and gold.

The stone may have been a yellowish green plasma (chalcedony) or, as suggested by King, a pale chrysoberyl; it is not the chrysoprase of the present day.

Huakinthos (Latin, *hyacinthus*): eleventh foundation.

Pliny describes the *hyacinthus* as being very different from *amethystus*, "though partaking of a colour that closely borders upon it," and as being of a more diluted violet.

It may have been the pale blue sapphire of the present day; the modern hyacinth or jacinth is a brownish to reddish zircon, a quite different stone.

Iaspis : first foundation.

Pliny recognises fourteen varieties of *iaspis*, and describes it as being generally green and often transparent. He adds that "many countries produce this stone : that of India is like *smaragdus* in colour ; that of Cyprus is hard and of a full sea-green ; and that of Persia is sky-blue. Similar to the last is the Caspian *iaspis*. On the banks of the river Thermodon the *iaspis* is of an azure colour ; in Phrygia it is purple ; and in Cappadocia of an azure-purple, sombre and not refulgent. The best kind is that which has a shade of purple, the next best being the rose-coloured, and the next the stone with the green colour of the *smaragdus*," etc., etc.

The term "jasper" is now restricted to opaque stones ; the transparent green *iaspis* may have been identical with the stone that is called "plasma" in the present day.

Sappheiros (Latin, *sapphirus*) : second foundation.

Pliny describes it as "refulgent with spots like gold. It is also of an azure colour, though sometimes, but rarely, it is purple ; the best kind being that which comes from Media. In no case, however, is this stone transparent."

These characters correspond to the lapis lazuli, not the sapphire, of the present day.

Sardion (Latin, *sarda*) : sixth foundation.

The *sarda* was much used by the seal-engravers. There were three Indian varieties, all of them transparent, one of them red in colour ; there was then no precious stone in more common use ; those of honey-colour were less valued.

It probably included the sard and carnelian of the present day.

Sardonx (Latin, *sardonyx*) : fifth foundation.

According to Pliny, the name *sardonyx* was at first given to an Indian (red) *sarda* with a layer of white in it, both being transparent. Pliny says that later three colours were considered essential, but that they might be repeated indefinitely. The Arabian *sardonyx* was "characterised by several different colours, black or azure for the base, and vermilion surrounded with a line of rich white for the upper part, not without a certain glimpse of purple as the white passes into the red."

It is included in the sardonyx of the present day.

Smaragdus (Latin, *smaragdus*): fourth foundation.

Pliny recognises no fewer than twelve kinds of *smaragdus*: the colour was intensely green.

One of these kinds was the emerald of the present day.

Topazion: eighth foundation.

The *topazion* of Pliny's time was "held in very high estimation for its green tints: when it was first discovered it was preferred to every other kind of precious stone." It was said to be brought from an island in the Red Sea, off the coast of Arabia. It was the only stone of high value that yielded to the action of the file.

It is termed peridot in the present day.

All the names of precious stones mentioned by St. John in his description of the foundations of the New Jerusalem, with the sole exception of *chalkēdōn*, were thus in his time commonly used by naturalists. Further, nearly all the stones then regarded as precious are included in the twelve mentioned by St. John.

The more important stones recorded by Pliny, but not mentioned by St. John as foundations, are:—

Crystallum and *Adamas*; both of them colourless.

Onyx; remarkable rather for structure than colour.

Electrum (amber); a soft material.

Carbunculus; fiery red.

Callaina; a pale green stone, probably the green turquoise of the present day.

Cyanus; of dark blue colour.

Opalus (opal); with its play of colours, it ranked in Pliny's time immediately after *smaragdus* in value.

Achates (agate) is also absent from the list of foundations; but *achates*, though previously held in very high esteem, by Pliny's time had ceased to be regarded as precious. Also, it is attractive for the beauty of its structure, whereas the foundations are remarkable for the splendour of their colours.

There is nothing to suggest that the name *chalkēdōn* was ever applied to any of these stones.

The colours of the foundations were:—

1st, (probably) Green; 2nd, Intense Blue; 3rd, *Chalkēdōn*; 4th, Intense Green; 5th, Red; 6th, Red; 7th, Yellow;

8th, Sea-Green ; 9th, Olive-Green ; 10th, Pale Green ;
11th, Pale Purple ; 12th, Purple.

From the arrangement of the colours it would therefore appear likely that the *chalkêdôn* was either a blue or a green stone, and that it might therefore be, as already suggested, the variety of *smaragdus* said by Pliny to have once been brought from a mountain near the free town called Chalcedon.

2. THE BREASTPLATE OF THE HIGH PRIEST.

Before discussing the other minerals mentioned in the New Testament, it will be best to consider the precious stones mentioned in the Old Testament, more especially those mounted in the Breastplate of the High Priest.

A. AUTHORISED VERSION.

Exodus 28 (17-21), Authorised Version :—

“ The first row shall be

a sardius (Hebrew, *ôdem*), a topaz (Hebrew, *pitdâh*), and a carbuncle (Hebrew, *bâréqeth*) : this shall be the first row.

And the second row shall be

an emerald (Hebrew, *nôphek*), a sapphire (Hebrew, *sappîr*), and a diamond (Hebrew, *yahâlôm*).

And the third row

a ligure (Hebrew, *lêshem*), an agate (Hebrew, *shêbô*), and an amethyst (Hebrew, *ahâmâm*).

And the fourth row

a beryl (Hebrew, *tarshîsh*), and an onyx (Hebrew, *shôham*), and a jasper (Hebrew, *yâshêphêh*) :

they shall be set in gold in their inclosings. And the stones shall be with the names of the children of Israel, twelve, according to their names, like the engravings of a signet ; every one with his name shall they be according to the twelve tribes.”

The long Captivity of the Jews in Babylon (about B.C. 606 to B.C. 534) had for result a change in the language spoken by the people ; after the return to Palestine the vernacular ceased to be Hebrew, and became a mixture of Hebrew and Chaldee. The old Hebrew ceased to be easily understood by the people (Neh. 8, 8). Hence there is now much difficulty in ascertaining the true meaning of words that occur but rarely in the Bible or elsewhere and have a technical signification, as in the case of precious stones.

Of the above twelve English names of the stones mounted in the Breastplate, we have already seen that seven occur in the Authorised Version of the New Testament as names of foundations of the New Jerusalem—sardius, topaz, emerald, sapphire, amethyst, beryl, and jasper; and it has been remarked that in giving these names the translators were merely giving in English form the Greek words *sardion*, *topazion*, *smaragdus*, *sappheiros*, *amethystos*, *bērullion*, and *iaspis*, that are used in the original text.

The remaining five English names—agate, diamond, ligure, onyx, and carbuncle—though not mentioned in the New Testament, also have similar verbal equivalents in the Greek language.

Agate, diamond, ligure, and onyx are the verbal equivalents of the Greek names *achates*, *adamas*, *ligurion*, and *onuchion*; carbuncle is the English equivalent of the Latin *carbunculus*, diminutive of *carbo*, (glowing) coal; and the Greek equivalent of *carbo* is *anthrax*.

Hence, if the English names of the stones in the Breastplate be re-translated into Greek names and arranged in the order of the English alphabet, the list will be as follows:—*achates*, *adamas*, *amethystos*, *anthrax*, *bērullion*, *iaspis*, *ligurion*, *onuchion*, *sappheiros*, *sardion*, *smaragdus*, and *topazion*.

B. SEPTUAGINT VERSION.

The Septuagint translation of the Old Testament into Greek, which was begun about B.C. 270 or 280, gives the above as the stones in the Breastplate, with one omission (*adamas*) and one addition (*chrusolithos*); the Greek and English translators of the Old Testament must, therefore, either have had a different Hebrew word in the manuscripts used by them, or have translated one or more Hebrew words differently.

In any case, the translation of a Hebrew name for a stone of the Breastplate into the English word "diamond" is certainly wrong, for the stone had a name engraved on it, and the method of engraving a diamond was not invented till two or three thousand years after the Breastplate was made; nor were diamonds, if known at all, then known so large as to be comparable in respect of size with the other stones of the Breastplate.

It is of interest to enquire into the correctness of the Septuagint translation of the various Hebrew names.

It should be remembered that, whereas the Breastplate had ceased to be known to be in existence long before the English translation was made, there was one in ceremonial use at Jerusalem till

the destruction of the city by Titus in the year A.D. 70, more than three hundred years after the Greek translation was completed. Even if the original Breastplate really vanished from history when Jerusalem was captured by Shishak, king of Egypt, about B.C. 973 (1 Kings 14, 25, 26 ; 2 Chron. 12, 9), or Nebuchadnezzar, king of Babylon, about B.C. 586 (2 Kings 24, 13 ; 25, 15 ; 2 Chron. 36, 18 ; Jer. 39, 8 ; 52, 13, 19 ; Dan. 1, 2), or Ptolemy Soter, king of Egypt, about B.C. 320, the one that had taken its place and was in use in the time of the Septuagint translators would presumably have been made to accord with the text of the Hebrew Scriptures ; on the other hand, it is very probable that during the Babylonian Captivity the knowledge of the characters of the stones of the vanished Breastplate, and of the meanings of the Hebrew names of the stones, had not been carefully passed down from one generation to another, and also that stones like those of the original Breastplate were not at the time available. Although the Septuagint translation was made at Alexandria, and direct comparison of the text with the Breastplate during the process of translation was therefore impossible, the version was afterwards in common use by the Jews at Jerusalem itself ; in fact, it eventually almost superseded the Hebrew text, for most of the quotations from the Old Testament given in the New are taken directly from the Septuagint. If the names given in that version for the stones of the Breastplate had not corresponded with the stones of the Breastplate then in use, the discrepancy would not have escaped the criticism of those Jews, perhaps few in number, who were familiar with the Greek names of the precious stones and could examine the Breastplate at Jerusalem. The names and arrangement of the stones in the Breastplate as stated in the Septuagint Version have for these reasons some claim to be treated as correct ; they are :—

	No. 1.	No. 2.	No. 3.
1st Row .	<i>Sardion</i> . .	<i>Topazion</i> . .	<i>Smaragdos</i>
2nd Row .	<i>Anthrax</i> . .	<i>Sappheiros</i> . .	<i>Iaspis</i>
3rd Row .	<i>Ligurion</i> . .	<i>Achates</i> . .	<i>Amethystos</i>
4th Row .	<i>Chrusolithos</i> . .	<i>Bêrullion</i> . .	<i>Onuchion</i>

It thus becomes important to ascertain what these Greek names indicated at the time the Septuagint translation was made, and for this purpose the Greek work of Theophrastus on Stones, though brief, is very useful. It is the earliest work on Minerals that has come down to us from ancient times. The author lived about B.C. 370–287, and therefore, though his book was probably completed

before the Septuagint translation was begun (B.C. 270 or 280), he must have been a contemporary of the translators themselves.

Of the above twelve names given in the Septuagint Version, only nine are mentioned in the book of Theophrastus, namely, *achates*, *amethystos* (in the form *amethuson*), *anthrax*, *iaspis*, *ligurion* (in the form *lugkurion*), *onuchion*, *sappheiros*, *sardion*, *smaragdos*.

The three not mentioned in the work of Theophrastus are *bêrullion*, *chrusolithos*, and *topazion*. It may be that the manuscript that has come down to us is incomplete, or that these three stones, though known to the Septuagint translators, were not known to Theophrastus, although their contemporary; or again, which is more likely, that they were known to Theophrastus, but under other names. He may, for instance, have regarded the green stones *bêrullion* and *topazion* as belonging to the genus *smaragdos* mentioned by him, and have called them only by the latter name. The *chrusolithos*, as already stated, was later mentioned by St. John as one of the foundations of the New Jerusalem, and described by Pliny in his Natural History. Further, all the more important stones regarded as precious in the time of Theophrastus are included in the Breastplate stones mentioned in the Septuagint Version.

Achates.—The *achates* of Theophrastus, said by him to have been called after a Sicilian river of that name, was in his day sold at a great price. By the time of Pliny it had ceased to be regarded as precious (p. 51).

Achates included certain stones having banded structures, the agates of the present day.

Amethystos.—The *amethuson* (*sic*) of Theophrastus was a transparent stone "resembling wine in colour," used by the gem engravers. It doubtless is included in the amethyst of the present day (p. 48).

Anthrax.—The *anthrax* of Theophrastus included different kinds of hard, red stone used by the gem engravers. It is the *carbunculus* of Pliny's time, and probably included the Oriental ruby (corundum), the Balas ruby (spinel), and the Almandine and Pyrope (garnet) of the present day.

Bêrullion.—This name is not mentioned by Theophrastus; *bêrullion*, in his time, may have been one of the green stones included in the genus *smaragdos* (p. 48).

Chrusolithos.—This name also is not mentioned by Theophrastus. The description given later by Pliny has been cited above (p. 49).

Iaspis.—The *iaspis* of Theophrastus was a hard stone used by the gem engravers. He makes no statement as to the colour, his descriptions of the precious stones being always very brief; it was probably a green stone, for he mentions a mineral specimen which was *iaspis* in one part and *smaragdus* in another, and states that in the opinion of some persons *smaragdus* is produced by the alteration of *iaspis* (p. 50).

Ligurion.—The *ligurion* of the Septuagint is probably identical with the *lugkurion* of Theophrastus: this was a yellow to yellowish red stone used by seal engravers, transparent, difficult to polish.

The yellow *ligurion* may be the yellow jargoon (zircon) of the present day, a stone which was much used by the ancient Greek and Roman engravers; but as the jargoon of the present day has not been found among ancient Egyptian work, it has been suggested that the figure of the Breastplate may have been a yellow quartz (citrine) or agate: the yellowish red *ligurion* may be one of the stones to which the name jacinth (zircon) is now applied.

Onuchion.—The *onuchion* of Theophrastus was a hard, translucent stone used by the seal engravers; it consisted of white and dusky layers in alternation.

The onyx of Roman times was an opaque stone of white and black layers.

Sappheiros.—The *sappheiros* of Theophrastus was a hard stone used by the gem engravers; he describes it as being "spotted as it were with gold."

This description was used later by Pliny in the description of the *sapphirus* of his day (p. 50), and doubtless the stones are identical with each other and with the lapis lazuli of present times.

Sardion.—The *sardion* of Theophrastus was a small, scarce stone used by the gem engravers.

It was probably included later in the *sarda* of Pliny (p. 50).

Smaragdus.—The *smaragdus* of Theophrastus was a small, scarce stone used by the gem engravers. As already mentioned under *iaspis*, that stone and *smaragdus* were probably both of them green. The genus might later include the green felspar (amazon stone); the latter was engraved in very early times, and is the material from which the signet of Sennacherib (about B.C. 700), preserved in the British Museum, was made (p. 51).

Topazion.—The name *topazion* is not mentioned by Theophrastus, and the green stone afterwards called by that name may, if known to him, have been included by him in *smaragdus*. Pliny's description has already been given (p. 51).

C. JEWISH ANTIQUITIES (JOSEPHUS).

A description of the Breastplate of the High Priest was published by Josephus in the first century of our era, and the description is of great importance from the fact that Josephus, having been a priest in the temple of Jerusalem, must have had frequent opportunities of closely inspecting the stones themselves. But it must be remembered that the Breastplate seen by Josephus may not have been identical with the one belonging to the time of the Septuagint translators: during the intervening three centuries the city of Jerusalem had been again, and more than once, in the hands of its enemies. In B.C. 198 the city was captured by Antiochus the Great; in B.C. 170 it was stormed, and its Temple plundered, by Antiochus Epiphanes (1 Maccab. 1, 20–24); in B.C. 54 the Temple was desecrated by Crassus.

Josephus was born in the first year of the reign of the Emperor Caius Caligula (A.D. 37); though the precise year of his death is unknown, he was still living near the end of the century; he was thus a contemporary both of St. John and Pliny, and Greek or Latin names then used for precious stones would have the same signification for all three writers. During the earlier Roman attacks on Palestine Josephus had been made Governor of Galilee by his countrymen, had been defeated, captured, put into irons and taken to Rome. After a time he was given his liberty, and, later, was allowed to accompany Titus, son of the Emperor Vespasian, to the siege of Jerusalem; Josephus was eventually an eye-witness of the destruction of the city (A.D. 70). One of the incidents of the destruction, recorded by him, is that a priest of the Temple was granted his life by Titus as a reward for delivering to the Romans "the precious stones and a great number of other precious vessels that belonged to their sacred worship." Josephus himself, towards whom Titus was very friendly, was allowed by that general to take possession of the Holy Books of the Temple. Later, he returned with Titus to Rome, and records that the spoils of the Temple, after being paraded in the Triumph, were placed by Vespasian in the Temple of Peace. If the Breastplate, as is possible, was part of the spoil, it could thus be inspected later by Josephus when writing

(A.D. 93) his account of the Antiquities of the Jews; though, if that ornament of the High Priest had actually passed with the other precious stones into the hands of the Roman general, a definite record would probably have been made. In any case he could compare his own description of the stones of the Breastplate (Book III, Chap. 7, par. 5) with that given in the Holy Books formerly preserved in the Temple of Jerusalem. Josephus was so great a favourite of Vespasian that he was given apartments in a house of that emperor. He wrote his account of Jewish Antiquities in Greek, and gave great attention to the study of the language, so that the literary style of his work might be worthy of its subject. Considerable accuracy can thus be claimed for the Greek names assigned by him to the stones of the Breastplate, which, according to his account, were extraordinary in largeness and beauty, and were an ornament not to be purchased by men because of their immense value. His list of the stones and that given in the Septuagint Version, if alphabetically arranged, are identical, except that *sardonux* in the former takes the place of *sardion* in the latter.

The term *sardonux* does not occur in the work of Theophrastus, and may have been invented after the time when the Septuagint translation was made. Pliny, whose description of *sardonix* has been quoted above, says that, according to Demostratus, the first Roman to wear a *sardonix* was the elder Africanus (about 200 B.C.), and that afterwards the stone was held in very high esteem at Rome. Doubtless the stone was known before the time of the elder Africanus, but was then included either in the sard or in the onyx.

This substitution by Josephus of the term *sardonux* for the *sardion* of the Septuagint is itself sufficient to suggest that he was writing from actual knowledge of the Breastplate; at any rate, he would not have been justified in using the new term *sardonux* instead of the old Septuagint term *sardion* for the first stone of the first row, unless he knew from direct observation that the stone belonged to that particular kind of *sardion* which has a white streak in it and is more definitely indicated by the newer term.

The arrangement of the stones in the Breastplate, according to the Jewish Antiquities of Josephus, was the following:—

	No. 1.	No. 2.	No. 3.
1st Row	<i>Sardonux</i>	<i>Topazion</i>	<i>Smaragdos</i>
2nd Row	<i>Anthrax</i>	<i>Iaspis</i>	<i>Sappheiros</i>
3rd Row	<i>Ligurion</i>	<i>Amethystos</i>	<i>Achates</i>
4th Row	<i>Chrusolithos</i>	<i>Onuchion</i>	<i>Bêrullion</i>

D. VULGATE VERSION.

The account of the Breastplate given in the Latin version of the Bible known as the Vulgate is also of importance. This translation was made about A.D. 400 by Eusebius Hieronymus, better known as St. Jerome, and is valuable as a help in the criticism of the present Hebrew text; for it is probable that St. Jerome, who lived many years at Bethlehem for the purpose of making a translation direct from the Hebrew, had access to Hebrew manuscripts which have by this time ceased to exist: the earliest dated Hebrew manuscript known to us was not written till five hundred years after his day. The version of St. Jerome became corrupted in the course of centuries, and in A.D. 1590 a revised text was given to the world by Pope Sixtus V., the present Standard Edition being issued three years later by Pope Clement VIII. In this edition of the Vulgate, the alphabetical list of the names of the stones, if they are literally re-translated into Greek, is again identical with that of the Septuagint Version; but the arrangement of the stones is given as the following:—

		No. 1.	No. 2.	No. 3.
1st Row		<i>Sardion</i>	<i>Topazion</i>	<i>Smaragdos</i>
2nd Row		<i>Anthrax</i>	<i>Sappheiros</i>	<i>Iaspis</i>
3rd Row		<i>Ligurion</i>	<i>Achates</i>	<i>Amethystos</i>
4th Row		<i>Chrusolithos</i>	<i>Onuchion</i>	<i>Bérullion</i>

COMPARISON OF THE ABOVE FOUR DESCRIPTIONS.

The arrangement of the stones in the Breastplate, according to the Authorised Version (A.V.), the Septuagint Version (S.V.), the Jewish Antiquities of Josephus (J.A.), and the Vulgate Version (V.V.), respectively, is therefore as follows:—

	No. 1.	No. 2.	No. 3.
1st Row	A.V. <i>Sardion</i>	A.V. <i>Topazion</i>	A.V. <i>Anthrax</i>
	S.V. <i>Sardion</i>	S.V. <i>Topazion</i>	S.V. <i>Smaragdos</i>
	J.A. <i>Sardonuz</i>	J.A. <i>Topazion</i>	J.A. <i>Smaragdos</i>
	V.V. <i>Sardion</i>	V.V. <i>Topazion</i>	V.V. <i>Smaragdos</i>
2nd Row	A.V. <i>Smaragdos</i>	A.V. <i>Sappheiros</i>	A.V. <i>Adamas</i>
	S.V. <i>Anthrax</i>	S.V. <i>Sappheiros</i>	S.V. <i>Iaspis</i>
	J.A. <i>Anthrax</i>	J.A. <i>Iaspis</i>	J.A. <i>Sappheiros</i>
	V.V. <i>Anthrax</i>	V.V. <i>Sappheiros</i>	V.V. <i>Iaspis</i>

	No. 1.	No. 2.	No. 3.
3rd Row	A.V. <i>Ligurion</i>	A.V. <i>Achates</i>	A.V. <i>Amethystos</i>
	S.V. <i>Ligurion</i>	S.V. <i>Achates</i>	S.V. <i>Amethystos</i>
	J.A. <i>Ligurion</i>	J.A. <i>Amethystos</i>	J.A. <i>Achates</i>
	V.V. <i>Ligurion</i>	V.V. <i>Achates</i>	V.V. <i>Amethystos</i>
4th Row	A.V. <i>Bērullion</i>	A.V. <i>Onuchion</i>	A.V. <i>Iaspis</i>
	S.V. <i>Chrusolithos</i>	S.V. <i>Bērullion</i>	S.V. <i>Onuchion</i>
	J.A. <i>Chrusolithos</i>	J.A. <i>Onuchion</i>	J.A. <i>Bērullion</i>
	V.V. <i>Chrusolithos</i>	V.V. <i>Onuchion</i>	V.V. <i>Bērullion</i>

Thus each of the four descriptions differs from the other three in the statement of the arrangement; but the Septuagint, the Antiquities of Josephus, and the Vulgate agree in the alphabetical list of the stones (except that *sardonux* is substituted by Josephus for *sardion*), and the Authorised Version differs from the other three, as already stated, through the inclusion of "diamond" and the omission of *chrusolithos*.

If the different arrangements of the stones of the Breast-plate, as given in the various versions, are compared, it will be seen that the Septuagint, the Jewish Antiquities of Josephus, and the Vulgate are in accord as regards the three stones of the first row (if *sardion* be taken to include *sardonux*), namely, *sardion*, *topazion*, and *smaragdos*; further, all three accord as regards the four stones of the first column, namely, *sardion*, *anthrax*, *ligurion*, and *chrusolithos*.

As regards the remaining six stones, the Vulgate is most nearly in accord with the Septuagint, the two arrangements being—

SEPTUAGINT.				VULGATE.	
	No. 2.	No. 3.		No. 2.	No. 3.
Second Row ...	<i>Sappheiros</i>	<i>Iaspis</i>		<i>Sappheiros</i>	<i>Iaspis</i>
Third Row ...	<i>Achates</i>	<i>Amethystos</i>		<i>Achates</i>	<i>Amethystos</i>
Fourth Row ...	<i>Bērullion</i>	<i>Onuchion</i>		<i>Onuchion</i>	<i>Bērullion</i>

there being a mere interchange of *bērullion* and *onuchion*.

For these six stones the arrangement given in the Jewish Antiquities of Josephus differs from that given in the Septuagint simply through the interchange of columns; the arrangement according to Josephus being—

	No. 2.	No. 3.
Second Row ...	<i>Iaspis</i>	<i>Sappheiros</i>
Third Row ...	<i>Amethystos</i>	<i>Achates</i>
Fourth Row ...	<i>Onuchion</i>	<i>Bērullion</i>

A Hebrew writer, in describing the arrangement of the stones, would begin with the stone on his right and describe them in the order right to left. A Western writer, on the other hand, would begin with the stone on his left and describe them in the order left to right. In translating from the Hebrew, a Western writer might translate either literally, adopting the Hebrew order, or more completely, adopting the Western order. But the above differences of statement of the arrangement are not such as would result in this way—for *ligurion* is the first stone of the third row according to all the above versions; reversal of the direction of reading would have made *ligurion* the last stone of its row.

It must therefore be inferred either that the descriptions correspond really to different Breastplates, the one in use at the time of the Septuagint translation, and the one in use in the time of Josephus, having been inexact reproductions of the destroyed original, or that the several versions given above were made from discordant Hebrew manuscripts, or that the translators have given different translations of the same Hebrew words, or that, in the description of the Breastplate, the original manuscripts of the Septuagint and Vulgate Versions and the Works of Josephus are not verbally identical with the printed editions of later times.

E. ANOTHER DESCRIPTION OF THE BREASTPLATE BY JOSEPHUS.

It remains to be mentioned that Josephus described the Breastplate, not only in his book on the Jewish Antiquities, but also in that on the Jewish Wars, and that these two descriptions, as they have come down to us, although made by the same writer, are not in evident accord with each other. It is desirable to trace, if possible, the origin of their differences, and to ascertain which of the two descriptions is the more likely to be correct.

The account of the Jewish Antiquities was written last, namely in A.D. 93. It deals with the history of the Jews from the earliest times down to the twelfth year of the reign of Nero. It was published only in Greek and for the information of the Gentiles. The work was written at greater leisure than the one dealing with the Jewish Wars, and the author had thus more time for the consultation of old manuscripts. Speaking generally, the later book, as would be expected, is more accurate as regards the history of the times before Josephus, of which he could have no direct knowledge, than the earlier work. The description that it gives

of the Breastplate is precise in respect of both the stones and their arrangement, and is therefore one to which great weight must be given.

The account of the Jewish Wars was written hurriedly, eighteen years earlier; it was written by Josephus in his native tongue for the information of those Jews in distant parts who wished to become acquainted with the events which had culminated in the destruction of Jerusalem. It was afterwards translated by the author into Greek, and published for the information of the Western nations. It deals chiefly with the time of Josephus himself, but is prefaced by a sketch of the history of the Jews from the capture of Jerusalem by Antiochus Epiphanes in B.C. 170. Its description of the Breastplate (Book V, Chap. 5, par. 7) is much less precise than the one in the Antiquities; translated into English, but with the above names for the stones, it is as follows:—

“On the other part there hung twelve stones, three in a row one way and four in the other: *sardion*, *topazion*, *smaragdos*, *anthrax*, *iaspis*, *sappheiros*, *achates*, *amethystos*, *ligurion*, *onuchion*, *bérullion*, *chrysolithos*.”

Attention may be called to several points in this brief description.

1. Josephus uses the term *sardion* for the stone that in the Antiquities he calls *sardonux*.

This is not a real inconsistency: in the time of Josephus a red stone having a white streak in it would be rightly called *sardonux* or *sardion*, according as stress was, or was not, laid on the presence of the streak.

2. Josephus does not definitely state that the order of the names in the list is identical with the order of the stones in the Breastplate.

It is quite possible that he relied on his memory when writing the paragraph, and did not refer to documents. It would be much more difficult, even for a man who had often seen the Breastplate, to remember the order of the stones than their names. The object he had in view at the moment was merely to give a rough idea of the Jewish religious ceremonies, and in this respect the actual arrangement of the stones in the Breastplate had little or no importance.

3. Josephus does not arrange the names of the stones in threes or fours; the original manuscript, like others of that time, presumably had no punctuation at all.

If, however, we ourselves, attempting to discover how he came to adopt this order for the names, break up the list into successive triads, it will be seen that the first three triads, namely :—

<i>sardion</i>	<i>topazion</i>	<i>smaragdus</i>
<i>anthrax</i>	<i>iaspis</i>	<i>sappheiros</i>
<i>achates</i>	<i>amethystos</i>	<i>ligurion</i>

are the first three triads according to the Antiquities, but that in the third triad the order of the names is precisely reversed.

The fourth triad, namely :—

<i>onuchion</i>	<i>bērullion</i>	<i>chrusolithos</i>
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differs from that of the Antiquities in that *chrusolithos* is placed after, instead of before, *onuchion* and *bērullion* : the order is thus only partially reversed : complete reversal would have given the order—*bērullion*, *onuchion*, *chrusolithos*.

Josephus, having put the *ligurion*, the first stone of the third row, at the right-hand end of the row, may have placed the *chrusolithos*, the first stone of the fourth row, on the same side, remembering that he had seen the *chrusolithos* immediately below the *ligurion* in the Breastplate, but forgetting the order of the other two stones.

Or, again, this triad is identical with the fourth row of the Septuagint Version, but the order is precisely reversed. Josephus may thus have had the Septuagint Version in mind and have described the row in the Jewish fashion ; having been accustomed from childhood to reading lines in the direction from right to left, he would be liable all through life to confusion of direction when expressing himself in a Western language.

Further, if Josephus, at the time of writing the account of the Jewish Wars, had attached any importance at all to the arrangement of the stones in the Breastplate, he would have refreshed his memory by reference either to the Holy Books of the Temple, which were then in his possession, or to the Septuagint Version with which he was familiar. The fact that eighteen years later, when giving a precise account of the Breastplate in the Jewish Antiquities, he adopted an order of the names which differs not merely from the order adopted by him in his history of the Jewish Wars, but from the orders given in the Holy Books and the Septuagint, at least as they are known to us, suggests either that the manuscripts accessible to him differed in this respect from those copies which

are preserved in our day, or that the stones of the Breastplate were different in his time from the stones which were in the Breastplate at the time the Septuagint translation was made. On the other hand, it is possible that our text of the Works of Josephus itself differs from the original.

3. THE STONES ON THE SHOULDER-PIECES OF THE EPHOD.

On each shoulder-piece of the Ephod, the vestment to which the Breastplate was attached, was a gold button having a precious stone set in it. The stones must have been of considerable size, for upon each of them were engraved the names of six tribes (Ex. 28, 9: A.V. Ex. 39, 6, or S.V. Ex. 36, 13).

The name of the stone in the Hebrew text as known to us is *shôham*. According to the Septuagint translators, who may not have seen the Ephod, for the character of their Greek indicates that they had long lived at Alexandria, the stone was *smaragdos*, and therefore green. According to Josephus, who had seen the Ephod, the stone was *sardonux*, and therefore red (with a streak of white in it).

The complete difference of colour suggests that these are not mere mis-descriptions of the same stones, but that the stones were *smaragdos* at the time when the Septuagint translation was made, and *sardonux* in the time of Josephus—a new Ephod having replaced the older one, perhaps after the capture of Jerusalem in B.C. 198 or B.C. 170.

The name of the middle stone in the fourth row of the Breastplate in our Hebrew text is likewise *shôham*, and this word is throughout the Authorised Version translated *onyx*.

The middle stone of the fourth row of the Breastplate, according to the Septuagint Version was *bêrullion* (not *onuchion*), and it is probably for this reason that the Revised Version gives *beryl* as an alternative rendering to *onyx* for the stone having that position. As already stated, *bêrullion* was not mentioned by Theophrastus, and may have been regarded by him as a variety of *smaragdos* (p. 55). In such case, the name of the stone set in the buttons and in the middle of the fourth row of the Breastplate may also have been *shôham* in the Hebrew text used by the Septuagint translators.

Professors Maskelyne and Sayce, accepting green as the colour of the *shôham*, have expressed the opinion that the stone known by that name in Septuagint and pre-Septuagint times was the stone

called *'siamu* by the Assyrians, and therefore the green turquoise of the present day; that stone may have been regarded by the more ancient Greeks and Romans, and therefore by the Septuagint translators, as a variety of *smaragdus* and as a kind of *bérullion*; later, in Pliny's time, it was probably included in *callaina*.

One more difficulty of interpretation may be mentioned.

The following phrase:—

“onyx stones, and stones to be set in (or for) the Ephod,
and in (or for) the Breastplate”

occurs in three places in the Authorised Version (Ex. 25, 7; 35, 9; 35, 27).

It is clear that only one kind of stone was in the mind of the writer of the Book of Exodus at the time of writing the word in these three passages which has been translated onyx; and in fact, in our Hebrew text, the word is in each case *shóham*. The only apparent reason for special mention of *shóham* in these passages is that the *shóham* stone was set both in the buttons of the Ephod and in the Breastplate; the other kinds of stone were set only in the latter. It is to be inferred from each of these passages that the stones set in the buttons were *shóham*, as definitely stated in the other verses mentioned. Yet in the corresponding passages in the Septuagint Version not one Greek word but two are used; the stone is called *sardion* in two places (S.V. Ex. 25, 7; S.V. Ex. 35, 8) and *smaragdus* in the third (S.V. Ex. 35, 27). Either the same Hebrew word was translated both *sardion* and *smaragdus*, or there were two Hebrew words in these passages of their Hebrew text; in the latter case it seems certain, from the sense of the passages, that one of the Hebrew words had been a result of mis-copying.

4. THE ORNAMENTS OF THE KING OF TYRE.

That the Hebrew manuscripts used by the several translators did actually differ from each other is very clear from the account of the Ornaments of the King of Tyre given in Ezek. 28, 13: “Every precious stone was thy covering, the sardius, topaz, and the diamond, the beryl, the onyx, and the jasper, the sapphire, the emerald, and the carbuncle, and gold.” For, whereas the Authorised Version just quoted names only nine stones, places gold at the end, and makes no mention of silver, the Septuagint Version gives twelve stones, mentions both gold and silver, and places these two metals in the middle of the list.

The nine stones mentioned in the Authorised Version are all included in the twelve previously mentioned in the description of the Breastplate, namely :—*adamas*, *anthrax*, *bērullion*, *iaspis*, *onuchion*, *sappheiros*, *sardion*, *smaragdos*, *topazion*; the three omitted being *achates*, *amethystos*, *ligurion*, the three stones in the third row of the Breastplate according to the Authorised Version, the Septuagint Version, the Vulgate Version, and the two descriptions by Josephus. This suggests that in the copying of the manuscript of Ezekiel the three stones that formed the third row of the Breastplate as described in the Book of Exodus had been accidentally omitted.

In the Authorised and the Vulgate Versions the order of mention of the stones in the description of the Ornaments of the King of Tyre is different; the two arrangements being as follows :—

AUTHORISED VERSION.

Sardion
Topazion
 [*Adamas*]
Bērullion
Onuchion
Iaspis
Sappheiros
Smaragdos
Anthrax.

VULGATE VERSION.

Sardion
Topazion
Iaspis
 [*Chrusolithos*]
Onuchion
Bērullion
Sappheiros
Anthrax
Smaragdos.

And in neither of these versions is the order of the nine stones of the Ornaments of the King of Tyre identical with any of the orders which have been assigned to the same stones in the various descriptions of the Breastplate of the High Priest.

On the other hand, in the Septuagint Version, not merely the names but also the orders of the names are identical in the descriptions of the Breastplate of the High Priest and the Ornaments of the King of Tyre; namely, *sardion*, *topazion*, *smaragdos*, *anthrax*, *sappheiros*, *iaspis*, (silver, gold), *ligurion*, *achates*, *amethystos*, *chrusolithos*, *bērullion*, *onuchion*.

DIFFICULTIES OF TRANSLATION OF HEBREW TECHNICAL TERMS.

Not only did the Hebrew manuscripts used by the Septuagint and English translators differ from each other, but the Septuagint translators met with difficulty in translating the Hebrew technical terms, as will be clear from a particular instance.

In the Hebrew text corresponding to the Authorised Version, the word *shóham*, designating one of the stones of the Breastplate, occurs in several places where there is no reference to other stones, and where accidental interchange of technical terms by the copyist could not occur; in the Authorised Version, as already stated, the word is always translated onyx. On the other hand, in the Septuagint Version of 1 Chron. 29, 2, the word is translated as *soam* stones, indicating that the Greek technical term for a *shóham* stone was unknown to the translator, and that he merely transliterated the name: in Exod. 28, 9; 35, 27; 39, 6 (or S.V. 36, 13), the word is translated *smaragdos* stones; in Gen. 2, 12, as *prasinos* (i.e. leek-green) stone; (the *prasites* of Theophrastus was a precious stone of a verdigris-green colour, and the name *prasinus* was used in still later times to signify a particular variety of *smaragdos*, namely, the true emerald): in Exod. 25, 7, and 35, 9 (or S.V. 35, 8), it is translated as *sardion* stones: in Job 28, 16, as *onux*. Assuming that the word in all these places is likely to have been *shóham* in the Hebrew original of the Septuagint Version, as in the Hebrew original of the Authorised Version, these differences suggest that there were different translators even for different parts of the Book of Exodus, and that little care was taken to arrive at consistency in the translation of the technical terms.

TRANSLATION OF HEBREW INTO GREEK AND ENGLISH TERMS.

In the preparation of their text, the translators of the Authorised Version have regarded the Hebrew, Greek, and English technical terms in the first three columns below as equivalent; the fourth column contains the English names that, according to the above, would now indicate stones to which the corresponding Greek names in the second column would probably have been given when the Septuagint translation was being made, or, still later, when the Book of Revelation was being written; the Hebrew names may have had other significations in pre-Septuagint times.

HEBREW.	GREEK.	ENGLISH (A.V. 1611).	ENGLISH (1911).
<i>Ahlámáh</i>	<i>Amethystos</i>	Amethyst	Amethyst
			Oriental ruby
<i>Bárégeth</i>	<i>Anthrax</i>	Carbuncle	Balas ruby
			Almandine
			Pyrope

HEBREW.	GREEK.	ENGLISH (A.V. 1611).	ENGLISH (1911).
<i>Léshem</i>	<i>Liqurion</i>	Ligure	{ Jargoon (yellow) Jacinth Quartz or Agate (yellow)
<i>Nóphek</i>	<i>Smaragdos</i>	Emerald	{ Emerald Amazon stone
<i>Ôdem</i>	<i>Sardion</i>	Sardius	{ Sard Carnelian
<i>Pitdáh</i>	<i>Topazion</i>	Topaz	Peridot
<i>Sappír</i>	<i>Sappheiros</i>	Sapphire	Lapis lazuli
<i>Shámír</i>	<i>Adamas</i>	{ Adamant Diamond	{ Diamond Corundum
<i>Shěbô</i>	<i>Achates</i>	Agate	Agate
<i>Shôham</i>	<i>Onuchion</i>	Onyx	Onyx
<i>Tarshish</i>	<i>Bērullion</i>	Beryl	{ Beryl Amazon stone
<i>Yahălôm</i>	<i>Adamas</i>	Diamond	?
<i>Yáshěphéh</i>	<i>Iaspis</i>	Jasper	Plasma

In the Authorised Version both *yahălôm* (Ex. 28, 18; Ezek. 28, 13) and *shámír* (Jer. 17, 1) have been translated diamond, and *shámír* also twice as adamant (Ezek. 3, 9; Zech. 7, 12); as already stated, *yahălôm* cannot be rightly translated diamond; *shámír* may have been either diamond or corundum in the times of Jeremiah, Ezekiel, and Zechariah (about B.C. 628–510).

Possibly some of the differences between the Septuagint Version and the Authorised Version are due, not to the differences of the Hebrew texts, but to the different meanings assigned by the different translators to the same Hebrew words: it has been suggested, for instance, that *báréqeth* and *nóphek* ought to interchange meanings, and again that *nóphek* may be the equivalent, neither of *smaragdus* nor of *anthrax*, but of *chrusolithos*; *yahălôm* the equivalent, not of *adamas*, but of *onuchion*; *tarshish* the equivalent, not of *bērullion*, but of *anthrax*.

ANOTHER TABLE OF EQUIVALENCE.

Having regard to the improbability that the Breastplate continued in existence, and was unaltered, from the time of Moses to that of Josephus, notwithstanding the many disasters that befel the Jewish nation during so long an interval, and to the certainty

that the Septuagint translators found great difficulty in the assignation of Greek names to the stones mentioned in the Hebrew text accessible to them, the late Professor N. S. Maskelyne, F.R.S., formerly (1857-80) Keeper of Minerals in the British Museum, held that no weight at all should be attached to the Septuagint names or to those given by Josephus, and sought to discover the old meanings of the Hebrew words in another way—namely, by comparison of the names that have been given to stones in various Oriental languages and by determination of the species of the minerals found among Egyptian and Assyrian Antiquities.

After much study, Mr. Maskelyne suggested (1888), though only tentatively and with much hesitation, the following as a list of probable equivalents of the Hebrew names of the Breastplate stones:—

HEBREW.	ENGLISH.
<i>Ahlámáh</i>	Onyx (?) or Amethyst.
<i>Báréqeth</i>	Almandine ; Amethyst (?) or Emerald.
<i>Léshem</i>	Yellow Jasper (?) or Amazon stone.
<i>Nóphek</i>	Blue Turquoise.
<i>Ôdem</i>	Red Carnelian or Red Jasper.
<i>Pitdáh</i>	Garnet or Peridot.
<i>Sappír</i>	Lapis lazuli.
<i>Shēbô</i>	Black-and-White Agate (?).
<i>Shóham</i>	Amazon stone or Green Turquoise.
<i>Tarshísh</i>	Green Jasper or Citrine.
<i>Yahálóm</i>	Glass or Blue Chalcedony or Beryl (?).
<i>Yáshēphéh</i>	Plasma.

5. OTHER STONES MENTIONED IN THE BIBLE.

(a) Other stones mentioned by name in the Bible are Alabaster and Crystal, and three which have had an organic origin, Amber, Coral, and Pearl.

Alabaster.—The *alabastrites* of Theophrastus was an onyx-marble (calcium carbonate) obtained in large masses from the neighbourhood of Thebes in Egypt.

In Pliny's time the most esteemed was of a honey-yellow colour "covered with spots curling in whirls and not transparent": it was considered defective when of a white or horn colour, or approaching glass in appearance. It was much

used for the preservation of precious ointments (Matt. 26, 7). The name alabaster is now generally given to a different compound of calcium, a sulphate (gypsum), a softer material.

Crystal.—The word occurs in the Authorised Version in Job 28, 17, and Ezek. 1, 22, and also three times in Revelation (4, 6; 21, 11; 22, 1). The Hebrew words in Job and Ezekiel are different, and are rendered in the Septuagint by the Greek words *hualos* and *krustallos*, respectively; *krustallos* is the Greek word used in Revelation.

The *krustallos* of Theophrastus was one of the hard, pellucid stones used by the seal engravers, and doubtless, like the *crystallum* of Pliny, was identical with the "rock-crystal" of the present time. Among the localities cited for *crystallum* by Pliny are "the crags of the Alps, so difficult of access that it is usually found necessary to be suspended by ropes in order to extract it."

The word "glass" occurs several times in the New Testament as a translation of the Greek word *hualos*: the name *hualos* was at first given to any clear, transparent stone, but in later times was restricted to glass. In the Authorised Version of the Old Testament, "looking glasses" are mentioned in Exod. 38, 8, Job 37, 18, and Ecclesiasticus 12, 11.

Amber.—The Greek name *elektron* occurs in the Septuagint (Ezek. 1, 4; 1, 27; 8, 2) as a translation of the Hebrew word *hashmal*; the *elektron* of the time of Theophrastus and the Septuagint translators is the amber of the Authorised Version and of the present day. In Pliny's time amber was an object of luxury, and ranked next to crystal.

Coral*.—The name occurs twice in the Authorised Version, both times in the Old Testament (Job 28, 18, and Ezek. 27, 16), and as a translation of the Hebrew word *ramóth*, but the correctness of the translation is doubtful.

Red coral has been highly esteemed since very ancient times. *Korallion* is described by Theophrastus as being red, cylindrical, resembling a root, and growing in the sea. In Pliny's time it was especially prized by the people of India, the reddest and most branched being most valued.

* See also p. 22.

Pearl.*—The name “pearl” occurs in the Authorised Version in Job 28, 18, and also seven times in the New Testament. In the Revised Version the Hebrew word (*gābīsh*) in Job 28, 18, is translated “crystal,” not “pearl.” The *margarites* (New Testament) is mentioned by Theophrastus as being one of the precious stones, but not pellucid, as produced both in a kind of oyster and in the *pinna*, and as brought from the Indies and the shores of certain islands in the Red Sea.

(b) The meanings of the four Hebrew terms *bēdōlah*, *eqdāh*, *kadkōd*, and *pēnīnim* have not been determined with certainty.

The first, *bēdōlah*, occurs twice (Gen. 2, 12; Numb. 11, 7), and is translated “bdellium” in the Authorised Version. Some commentators think that the name is that of the gum of an Arabian tree; others interpret it to be an “excellent, selected pearl.”

The second, *eqdāh*, occurs once (Isa. 54, 12); in the Authorised Version it is translated as “carbuncle,” and in the Septuagint as *krustallos*.

The third, *kadkōd*, occurs twice (Isa. 54, 12; Ezek. 27, 16), and in the Authorised Version is translated, like the Hebrew word *shēbō*, as “agate.” The true interpretation is very doubtful; ruby, zircon, garnet, and tourmaline have all been suggested.

The fourth, *pēnīnim*, occurs in Job 28, 18; Prov. 3, 15; 8, 11; 20, 15; 31, 10; Lam. 4, 7. In the Authorised Version it is translated “rubies”; but in the Septuagint it is translated as being equivalent to “precious stones.” It has also been suggested that the word may mean “red coral,” as it has some likeness to an Arabic word meaning “branch”; it has also been thought that the word means “pearls.”

(c) Of the remaining materials mentioned in the text or marginal references of the Bible, the following are so well known that description is unnecessary:—

1. The Metals:—

Gold.

Silver.

Brass: really the material signified was generally bronze, *i.e.*, copper alloyed with tin; but sometimes, possibly, it may have been true brass, *i.e.*, copper alloyed with zinc.

Tin.

Lead.

Iron.

* See also p. 22.

The word translated "steel" in the Authorised Version is translated *chalkos* (*i.e.*, bronze) in the Septuagint.

2. The Inflammables :—

Coal.

Bitumen, Pitch (Slime).

Naptha (Naphtha).

Brimstone.

3. The Salts :—Common salt and nitre ; the latter being the *nitron* of former times, which was a carbonate of sodium, not the nitre of the present day.

The others are very indefinite in character, or of common occurrence, namely—

Clay, Mire, Ashes, Dust, Earth ;

and Rock, Stone (with Chalkstone, Gravelstone, Headstone, Millstone), Sand, Flint, Porphyry (Porphyre), Marble, and Lime.

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BRITISH MUSEUM (NATURAL HISTORY)
SPECIAL GUIDE No. 6

GUIDE TO THE EXHIBITION
OF SPECIMENS ILLUSTRATING
THE MODIFICATION OF
THE STRUCTURE OF ANIMALS
IN RELATION TO
FLIGHT



LONDON
PRINTED BY ORDER OF THE TRUSTEES
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1913

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THE BRITISH MUSEUM.



Wings of a Pterodactyle, a Bat and a Bird. In the Pterodactyle (upper figure) the wing-membrane is supported mainly by the long fifth finger; in the Bat (middle figure) the wing-membrane is supported mainly by the third, fourth and fifth fingers; in the Bird (lower figure) the overlapping feathers form an almost impervious layer for beating the air (see 85).

From Sir E. R. Lankester's *Extinct Animals*, 1905, p. 233.

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P. 7. 1. 1. 1. 1.

LONDON:

PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
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P R E F A C E .

AT the present time, when such rapid advances are being made in the efficiency of aeroplanes and the control of navigable balloons, and when so much attention is being given by inventors to the construction of machinery adapted to the requirements of aviation, it becomes a matter of particular interest to consider the various modifications of structure by which animals have attained command of the air; and the present exhibition, comprising 166 mounted objects and 12 microscopic specimens, has been arranged for the purpose of elucidating the subject in a popular manner.

In the series of specimens exhibited the adaptation of each kind of flying animal for aerial locomotion is explained, and the changes that must have taken place in the structure of the body before the animal could really fly are indicated; and attention is drawn to the remarkable fact that the power of flight has been evolved independently in different groups of animals—Bats, Birds, Pterodactyles and Insects.

In all the human attempts at aviation that have met with any degree of success the part of the apparatus that sustains the weight in the air (planes or gas-bag, as the case may be) is distinct from the driving apparatus (propeller and its engine); but a study of the specimens here displayed shows that in flying animals the energy is generated by the contraction of muscles directly connected with the wings, and that the latter, by a regular beating or flapping action, both support the body in the air and force the body through it.

Among the exhibited specimens are preparations illustrating the mechanical principles involved in the linkage and leverage of the skeletal parts, dissections and models explaining the action of the power-producing apparatus (elevator and depressor muscles) and its relation to the skeletal parts, prepared specimens showing

the structure and shape of the flight membranes, and specimens explaining the mode of folding of the wings when at rest.

The exhibition is not limited to animals that can truly fly, but includes also examples of animals which move through the air by scudding, gliding or parachuting, without expending energy from the time when they leap off to the time when they alight, such as the so-called Flying Squirrels, Flying Phalangers, etc.

The selection and preparation of the specimens for exhibition, and the writing of this Guide-book are the work of Dr. W. G. Ridewood.

For the frontispiece the Trustees of the British Museum are indebted to Messrs. A. Constable and Co., Ltd.; of the 44 text-figures, 26 have been specially drawn, and most of the remainder have appeared in guide-books previously published by the Trustees; for figs. 5 and 8 acknowledgment is due to Messrs. A. and C. Black, and for figs. 15 and 17 to Messrs. Macmillan and Co., Ltd.

L. FLETCHER,

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July, 1913.

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MODIFICATION OF THE STRUCTURE OF ANIMALS IN RELATION TO FLIGHT.

INTRODUCTION.

THE cases containing the specimens illustrating the structure of flying animals are all situated on the East* side of the Central Hall, in the Bay or Recess marked VII.†

The series exhibited includes various kinds of animals which agree in possessing some capacity for moving through the air. Of these animals, some are capable of true flight, propelling themselves through the air by a flapping of wings, *e.g.* Birds, Bats, Pterodactyles‡ and Insects. Others are enabled by some form of outspread membrane or fold of skin to break their fall when leaping from a branch, and by adopting an oblique attitude in their descent to scud for considerable distances through the air, *e.g.* Flying Lemurs, Flying Squirrels, Flying Phalangers, Flying Lizards, Flying Snakes, etc.

The independent modification of parts of the body for the purpose of aerial locomotion in the different groups of animals is of considerable interest in the light of the theory of "evolution." The wings of the Bird, Bat and Pterodactyle (see frontispiece) are

* The entrance of the Museum is at the *South* end of the Central Hall, and the main staircase is at the *North* end; the side of the Hall to the right of the visitor on entering is the *East*.

† The Bays or Recesses around the Central Hall are denoted by numerals. On the *East* side, the Bay nearest the Huxley statue is No. X, and that by the side of the main staircase is No. VI.

‡ The Pterodactyles being extinct, the evidence of their capacity for flight is necessarily indirect, and the conclusion presumptive.

instances of homoplasy, or convergence, being structures evolved independently as organs of true flight in three separate divisions of the Vertebrate phylum, Birds, Mammals and Reptiles; and they are not to be explained as wings inherited as functional organs of flight from the ancestral stock from which all Birds, Bats and Pterodactyles have originated. This is shown by the fact that, although in these three groups of Vertebrates it is the pectoral limb that has been transformed into a wing; yet the transformation has been effected differently in the three cases. In all three groups the fundamental type of limb skeleton is the same, and such bones as the humerus, radius, ulna, carpal bones, metacarpal bones and phalanges can be clearly and readily identified (see 85).^{*} Yet in the Bats the skin-fold is stretched between the arm bones and the greatly elongated bones of the second, third, fourth and fifth fingers, and extends along the body to include the hind leg and tail; in the Pterodactyles the skin-fold is supported by the bones of the arm and leg and the great fifth finger, the second, third and fourth fingers being free; in the Birds the resistance to the air is afforded, not by a fold of skin, but by a layer of feathers, which are attached at their basal ends to the bones of the arm and hand.

The wings of Insects are again different. They are not transformed limbs as are the foregoing, but are expansions of the outer case or exo-skeleton, and project sideways from the back of the animal. Further than this, the wings are in typical instances two pairs in number, although in many cases, *e.g.* Moths, Wasps and Water-Bugs, there are special locking devices by which the two wings of the same side act together as one sheet.

In all these cases (Birds, Bats, Pterodactyles and Insects) the wings are hinged at their bases, and provided with powerful muscles, so that they can be raised and depressed, and thus made to beat the air and maintain the body in, and propel it through the air.

In the gliding Mammals, the so-called Flying Lemurs (*Galeopterus*), Anomalures (*Anomalurus*, *Idiurus*), Flying Squirrels (*Petaurista*, *Sciuropterus*, etc.) and Flying Phalangiers (*Petaurus*, etc.), there is presented another instance of homoplasy, the fold of skin by which the animal is enabled to scud or glide downward

^{*} The specimens exhibited bear distinctive numbers printed in large figures. The numerals quoted in brackets in this guide-book refer to the specimens bearing those numbers, and the numerals printed in heavy type at the beginning of the paragraphs in the body of the guide-book have the same significance.

through the air being a new development in each of the separate groups of Mammals, and not a structure possessed by the common ancestors of these groups. Indeed, there is a probability that even within the group Marsupialia the patagium or skin-fold has been independently evolved in the three Australian genera *Petaurus*, *Petauroides* and *Acrobates*, for these are not closely related Phalangers.

In the cases just mentioned the skin-fold or patagium is held in position during the act of gliding by the outstretched arms and legs, and in some cases the tail, but in the Flying Lizard (*Draco*) the arms, legs and tail are free, and the fold of skin at the side of the body is supported by certain of the ribs which are greatly elongated for the purpose.

The question of flight in the Flying Fishes is a vexed one. There can be no doubt, from the records of careful observers, that the greatly expanded pectoral fins of *Exocoetus* are agitated as the fish moves through the air, but it would appear that any flapping of the fins as wings that does occur is of less importance than the service rendered by the fins in checking the descent of the fish into the water again (see 44-46).

It is of interest to note that the only animals that fly are either Vertebrates or Insects. The so-called Flying Copepods (see 100), minute oceanic Crustaceans, merely spring out of the water and fall back again, and thus have less claim to be regarded as flying animals than even the Flying Squirrels and Flying Lizards. The Parachute Spider of Australia, *Attus volans* (97), also, cannot be regarded as a flying animal. It is a very small jumping Spider with little flaps at the sides of the abdomen which enable it to take longer leaps than other Spiders of the same size.

CASE I.

MAMMALS.

BATS.

1-2. A Bat (Fox-Bat or Flying Fox, *Pteropus giganteus*) mounted in the attitude of flight, and a skeleton of the same species with the bones arranged as they would be disposed in the flying animal.

Bats are the only Mammals possessing the power of true flight; the Flying Lemurs, Flying Squirrels and Flying Phalangers

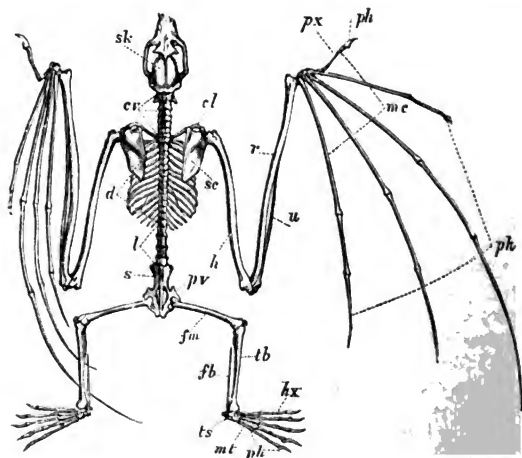


Fig. 1.—Skeleton of a Bat (Fox Bat or Flying-Fox, *Pteropus giganteus*), showing the elongation of the bones of the arm and hand for the support of the large wing-membrane (see 2). *cl*, clavicle; *cv*, cervical vertebrae; *d*, dorsal vertebrae; *fb*, fibula; *fm*, femur; *h*, humerus; *hx*, great toe, or hallux; *l*, lumbar vertebrae; *mc*, metacarpals; *mt*, metatarsals; *ph*, phalanges; *pv*, pelvis; *px*, thumb, or pollex; *r*, radius; *s*, sacral vertebrae; *sc*, scapula; *sk*, skull; *tb*, tibia; *ts*, tarsus; *u*, ulna.

are able to scud down through the air, but they cannot beat the air and rise in it to a higher level.

The wing-membrane of Bats is a double fold of skin (see 5),*

* See footnote on page 2.

which extends outward from the side of the body and hind legs, and encloses and is supported by the bones of the arm, fore-arm and hand. The thumb is mostly free and has a claw (frontispiece, middle figure), the second digit is in insect-eating Bats set close to the third without any considerable extent of membrane between; the greatest expanse of membrane is between the side of the body and the fifth, fourth and third fingers. In some Bats (insect-eating Bats in particular) there is also a membrane between the legs, supported in the middle by the tail, but this membrane does not share in the flapping of the wings. In fruit-eating Bats the tail is mostly short, and the interfemoral membrane is reduced or wanting.

With few exceptions Bats are nocturnal in habit; the eyes are in many cases reduced, and the external ears are frequently of great size, and in some Bats there are large leaf-like expansions of sensitive skin around the nostrils which enable the animals to steer a clear course between trees and rocks, and to recognise and pursue the insects on which they feed.

In size Bats vary from the small animals found in this country to the great edible Bat (*Pteropus vampyrus*) of Java, which measures five feet across the fully extended wings.

In the skeleton the chief points to be noticed are the elongation of the bones of the third, fourth and fifth digits, the elongation of the radius and the slenderness of the ulna (fig. 1). The keel of the sternum is seen in side view in specimen 6 (fig. 2).

3. A Bat, *Pteropus giganteus*, showing the mode of folding of the wings when at rest. The right wing is shown partially closed, the left completely closed.

When settling, the Bat hangs head downward by its toes from the branch of a tree or the edge of a rock, the curved claws pointing towards the front of the animal, owing to a curious rotation which the leg bones have experienced.

In the closing of the wing the angle between the arm and the fore-arm becomes reduced until the latter lies alongside the former. At the same time the bones of the hand approach one another until they become nearly parallel to the fore-arm, so that the whole of the wing is brought up close to the side of the body. The closed wing then wraps over the chest and abdomen, and protects these parts during the period of rest.

4. *Taphozous nudiventris*, a Bat of the family Emballonuridae. In most Bats the middle or third digit of the wing can in a state of repose be bent more or less towards the ventral surface, but in

the Bats of the family Emballonuridae the phalangeal portion of the third finger bends back on the dorsal surface of the wing, and to such an extent that the first phalangeal bone comes to lie parallel with the metacarpal bone.

5. Right wing of a Bat (*Pteropus vampyrus*) with the membrane between the ulnar bone and the fifth digit partially split to show that it is composed of two separable layers of skin. Compare with this the preparation of the Moth's wing, 101.

6. Portion of skeleton of a Bat (*Pteropus vampyrus*), left side, showing the extent of the keel of the sternum for the attachment of the depressor muscles of the wings (fig. 2).

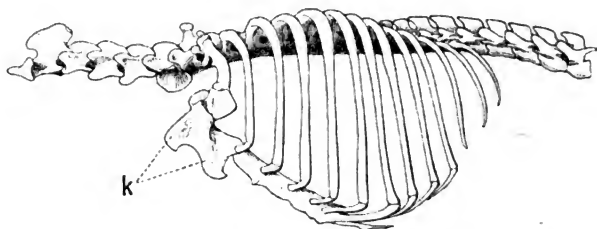


Fig. 2. — Thoracic skeleton of a large Fruit Bat (*Pteropus vampyrus*), together with the cervical and lumbar vertebrae, seen from the left side. *k*, the keel of the sternum, to which the depressor muscles of the wings are attached (see 6).

7-8. Dissection of the shoulder of a Bat (Fruit Bat, *Pteropus vampyrus*) and explanatory sketch (see fig. 3). In Bats the principal muscles concerned in elevating and depressing the wing during flight are the *deltoideus* and the *pectoralis major*. The *deltoideus* (shown in blue in the explanatory sketch) on contraction raises the wing; it is inserted into the upper * part of the first bone of the wing (humerus), and takes its origin from the upper surface of the shoulder blade (scapula) and from a high-standing process of it (the acromion). The scapula itself is not a rigid part of the skeleton, but is held in position by the contraction of the *trapezius* and other muscles. The *pectoralis major* (shown in red in the explanatory sketch) is the largest muscle in the body of the Bat, and by its contraction brings about the depression of the wing during flight. It arises mainly from the side of the

* I.e. dorsal in the extended wing.

sternum, but partly from the clavicular bone. It is inserted into the anterior and under surface of the basal end of the humerus, which bone is freely hinged with the scapula. The drawing forward of the extended wing is effected mainly by the clavicular

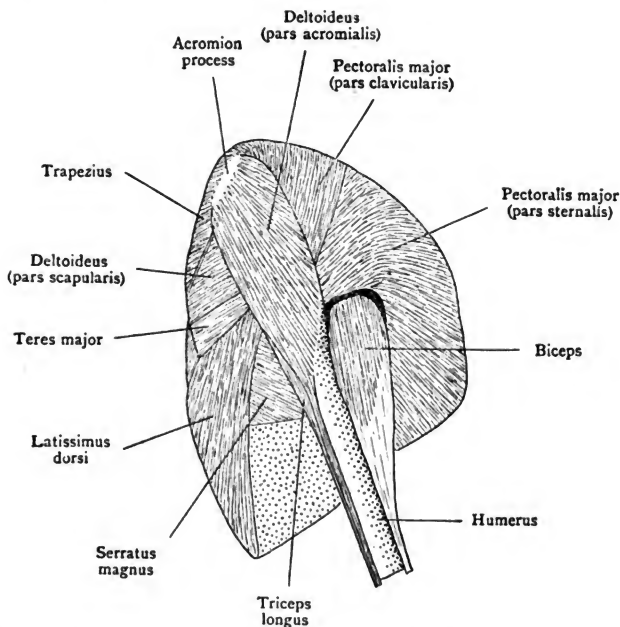


Fig. 3.—Dissection of the shoulder of a Bat (Fruit Bat, *Pteropus vampyrus*), showing the principal muscles that move the wings during flight (see dissection 7).

part of the *pectoralis major*, with which is intimately associated a clavicular part of the *deltoideus*, not shown in the dissection; the drawing back of the wing is brought about chiefly by the *teres major* and the *latissimus dorsi*.

9. Simple model to illustrate the mechanical principles involved in the elevating and depressing of the wing of a Bat. The brass lever, representing the wing, is hinged upon a brass

frame, the upper, plate-like piece of which stands for the scapular bone, and is held in position by white cords (*trapezius* and other muscles), while the lower, rod-like piece stands for the clavicular bone, and is rigidly fixed at its inner end against a piece of board which occupies the position of the middle plane of the body. The brass lever is actuated by two cords. The upper one (blue), standing for the deltoid muscle, is attached to the upper surface of the brass plate; the lower one (red), standing for the great pectoral muscle, is attached to the board at a part which may be considered as the equivalent of the keel of the sternum. Both of these cords are tied to the lever at points more remote from the middle plane of the body than the fulcrum or centre of rotation. If the blue cord be tightened and the red cord slackened the lever rises; if the red cord be tightened and the blue cord slackened the lever is pulled down. The tightening and slackening of the cords find their equivalents in the Bat in the contraction (shortening) and relaxation (release from shortening) of the muscles.

10. Photograph of Indian Fruit Bats (*Pteropus giganteus*) in flight.

FLYING LEMURS.

11. Flying Lemur, *Galeopterus volans* (fig. 4). The species of *Galeopterus* (*Galeopithecus*) constitute the group of Mammals called Dermoptera, and although called Flying Lemurs, are allied to the Insectivora rather than to the Lemurs. They subsist, however, mainly upon vegetable food. A patagium or extension of the skin at the sides of the body between the fore and hind legs, and extending forward to the neck and backward to the tail, and even between the fingers and toes, forms a kind of parachute, which enables the animal to float or glide through the air from tree to tree. The animals cannot fly, nor rise in the air; their movements in the air are always those of descent. The Flying Lemurs occur in the Malay Archipelago; they are nocturnal in habits, and in the daytime hang head downward from the trees. Flying Lemurs are sometimes called Taguans, but this term has also been applied to the Flying Squirrels and the Flying Phalangers.

RODENTS.

12-14. Asiatic Flying Squirrels, *Sciuropterus nigripes*, from the Philippine Islands, *Petaurista nitida rajah*, from Borneo, and

Petaurista leucogenys, from Japan. The species of *Petaurista*,* *Sciuropterus* and allied genera are arboreal Rodents of the family Sciuridae, occurring mostly in the Oriental region, although species are found in North America, Eastern Europe and Siberia. They have a skin-fold or patagium extending along the side of the body between the fore and hind limbs, and continued feebly along the neck, and in *Petaurista* for a short distance along the base of the tail. In *Sciuropterus* the flank membrane is relatively narrower than in *Petaurista*, and the tail is flatter. In some



Fig. 4.—Flying Lemur (*Galeopterus volans*), showing the fold of skin along the side of the body which enables the animal to glide through the air (see 11).

species of *Petaurista* (14) the tail is bushy. The Flying Squirrels cannot fly, but the patagium enables them to leap greater distances than ordinary Squirrels. They at first descend in a long swoop, sometimes as much as 60 or 70 yards, and rise slightly just before reaching the bough upon which they intend to alight. Flying Squirrels are nocturnal in habit, and spend the day in hollow trees, where they generally associate in colonies.

* Formerly *Pteromys*.

15. Tail of *Sciuropterus sagitta*. The tail is flattened, and somewhat resembles the flat bristly tail of the small Anomalure *Idiurus macrotis*, 17.

16-17. African Flying Squirrels, or Anomalures, *Anomalurus fraseri* and *Idiurus macrotis*, from the Cameroons. The species of *Anomalurus* (fig. 5), *Idiurus* and allied genera are arboreal



Fig. 5.—An African Flying Squirrel (*Anomalurus fulgens*), showing the fold of skin along the side of the body which enables the animal to glide through the air (see 16).

From *Study of Mammals*, by Flower and Lydekker, 1891, p. 449; after Alston, *Proc. Zool. Soc.*, 1875.

Rodents of the family Anomaluridae, occurring mostly in West and Central Africa. They present a strong superficial resemblance to the true Flying Squirrels, although their relationship to the Sciuridae is rather remote. They have a skin-fold or patagium extending along the side of the body between the fore and hind limbs, feebly developed in front of the fore limb and behind the hind limb, and not extending along the tail. The animals cannot fly, but the patagium enables them to glide or scud down obliquely

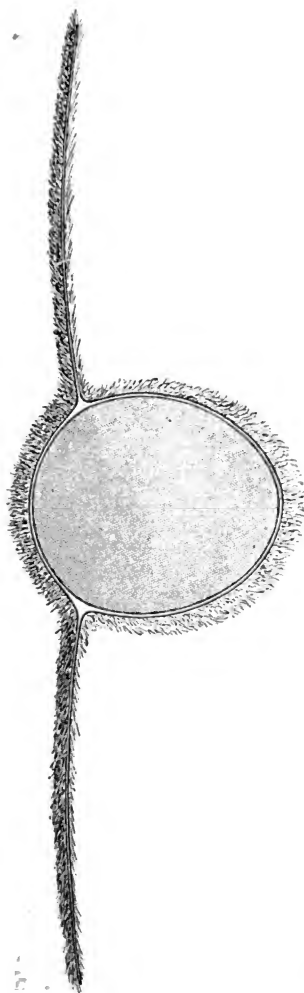


Fig. 6.—Section across the body of an African Flying Squirrel (*Anomalurus beecrofti*), about mid-way between the fore and hind limbs, showing that the patagial membrane consists of skin only—two layers of skin, with thick fur above and scanty hairs below. The drawing is about two-thirds of the natural size (see 18).

for long distances from one branch to another. The under surface of the root of the tail has a double row of spiny scales which assist the animal in climbing trees. Anomalures are sometimes termed Scaly-tailed Flying Squirrels.

18. Middle portion of the body of an African Flying Squirrel (*Anomalurus beecrofti*), seen from behind (fig. 6). The patagial membrane arises fairly high up the side of the body, and consists of skin only—two layers of skin, with thick fur above and scanty hairs below.

19. Skeleton of an African Flying Squirrel, *Anomalurus erythrogaster*, showing that the patagial fold of skin between the fore and hind limbs has no skeletal support other than the rod of cartilage (C) which projects from the elbow.

20-21. Skeleton of the right fore limb of an African Flying Squirrel, *Anomalurus beecrofti*, and of an Asiatic Flying Squirrel,

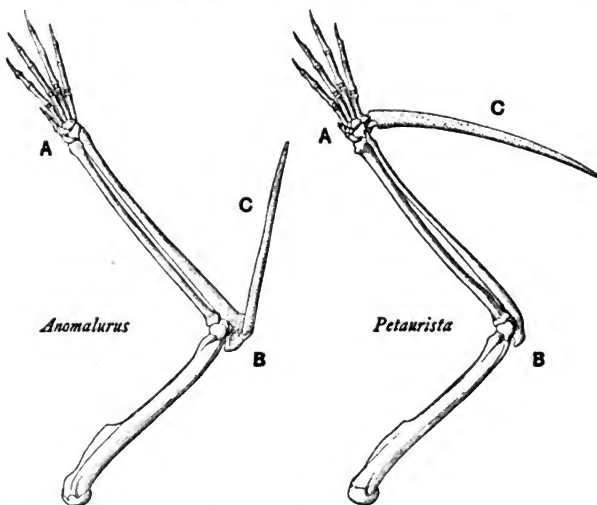


Fig. 7.—Skeleton of the fore limb of an African Flying Squirrel (*Anomalurus beecrofti*) and an Asiatic Flying Squirrel (*Petaurista magnificus*). In the former the cartilaginous rod that stiffens the front part of the patagial membrane arises from the elbow; in the latter it arises from the outer edge of the wrist. A, wrist; B, elbow; C, rod of cartilage (see 20-21).

Petaurista magnificus, showing the rod of cartilage which stiffens the patagial membrane. Of interest, as tending to show that in the African Flying Squirrels and the Asiatic Flying Squirrels the lateral patagial membrane has been independently evolved, is the fact that the membrane in the former is supported by a rod of cartilage that projects outward from the elbow, while in the latter the support is afforded by a rod of cartilage projecting from the wrist (fig. 7). Such rods of cartilage do not occur in the skeletons of ordinary Squirrels.

MARSUPIALS.

22-24. Flying Phalangers, *Petaurus breviceps*, *Petauroides volans* and *Acrobates pygmaeus*. The Flying Phalangers of Australia are species of unrelated genera of Marsupials, *Petaurus*



Fig. 8.—A Flying Phalanger (*Petaurus sciureus*), showing the fold of skin along the side of the body which enables the animal to glide through the air (see 22).

From *Study of Mammals*, by Flower and Lydekker, 1891, p. 154.

(fig. 8), *Petauroides* and *Acrobates*, with soft silky fur and a skin-fold or patagium extending along the side of the body between the fore and hind limbs, and feebly developed along the front edge of the fore limb. These Phalangians cannot fly, but the patagium enables them when leaping from a high branch to glide or float obliquely down to a lower branch of some distant tree.

25. A young Flying Phalanger, *Petaurus breviceps*, showing that the patagial membrane is relatively less developed in the young than in the adult. Compare with the adult, 22.

26. Skeleton of a Flying Phalanger, *Petaurus australis*, showing that there are no skeletal supports for the patagial membrane other than the limb bones (contrast with 20-21).

REPTILES.

PTERODACTYLES.

Pterodactyles (Ornithosauria or Pterosauria) are extinct winged Reptiles, which lived in the Secondary or Mesozoic Period, and the remains of which are found in England, Germany, Kansas, etc. The wings are large (figs. 9 and 10), and the support of the wing-membrane is afforded by the bones of the arm, the greatly enlarged fifth finger,* and the leg. The digits of the hand, other than the fifth, are slender, and the hind foot has four feeble digits furnished with claws, and in some cases a fifth toe is present in addition. The tail is long in some, and short in others. There is a slight keel to the sternum, far less prominent than in flying Birds. In size the Pterodactyles range from small animals no larger than Sparrows to others with a wing span of 18 feet.

27. Drawing of the restored skeleton of *Pteranodon*, a great Pterodactyle from the Cretaceous of Kansas, etc. (fig. 9). The span across the wings is about 18 feet. The skull is prolonged into a sharp toothless beak, and the hinder part of the skull is produced into a bony spine. The tail is extremely short. A restored skeleton of *Pteranodon* is exhibited in the Geological Department of the Museum, and a restored model is shown over the doorway leading from the Reptile Gallery towards the Shell Gallery in the Zoological Department.

* That the great wing-finger is the fifth is the generally accepted view, but Williston (*Journ. Geol., Chicago*, xix, 1911, p. 696) is disposed to revert to Cuvier's interpretation of the digit as the fourth.

28. Restoration (natural size) of the sternum of *Pteranodon*, a great Pterodactyle from the Cretaceous of Kansas, etc. The lateral edges of the sternum have articulations for four or five pairs of ribs. The hinder part of the sternum is an extremely thin plate of bone; the front part, or manubrium, is massive, and on its upper surface has two articular facets for the large coracoid bones. Unlike flying Birds the Pterodactyles have but a slight keel to the sternum for the attachment of the muscles of flight.

29. Cast of the anterior portion of the sternum of *Ornithochirus*, a great Pterodactyle from the Cambridge Greensand of Cambridge, etc. The specimen is seen from the left side.

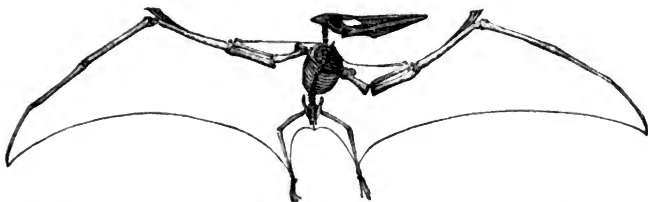


Fig. 9.—Skeleton of a very large Pterodactyle, or Flying Reptile (*Pteranodon occidentalis*), from the Cretaceous of Kansas. The span across the wings is about 18 feet.

30. *Pteranodon* sp., notarium or mass of fused anterior thoracic vertebrae, ventral view; from the Upper Cretaceous of Kansas. Compare 31, fig. 4.

31. Four figures of the notarium (fused mass of anterior thoracic vertebrae) of *Pteranodon* sp. Fig. 1, left side view; fig. 2, oblique view; fig. 3, dorsal view; fig. 4, ventral view. (From G. F. Eaton, "Osteology of *Pteranodon*," Mem. Connecticut Acad., Arts and Sciences, vol. ii, 1910, pl. viii.)

While in all but certain aquatic Vertebrates (Fishes, Whales, Sirenians) and some Snakes (Python, Boa) the upper bones (ilia) of the pelvic girdle are regularly connected with a fused mass of vertebrae (the sacrum)*, a connection between the upper bones (scapulae) of the pectoral girdle and a fused mass of vertebrae (the notarium) is very unusual. It occurs in the Pterodactyles and in Skate-like Fishes.

* In most Frogs the sacrum consists of one vertebra only.

Figs. 1 and 2 show the lateral depression in the upper ridge of bone into which the upper extremity of the scapula fits.

32. Ulnar bone of a large Pterodactyle, *Ornithochirus* sp., from the Lower Chalk of Snodland, Kent. In Pterodactyles, as in Birds, many of the bones are pneumatic; they are very thin in texture, and the interior was occupied in life by air-sacs in communication with the lungs. In the specimen here shown the thinness of the bone is apparent in the fractured parts.

33. Restored model, one-fourth (linear) of the natural size, of *Dimorphodon macronyx*, from the Lower Lias of Lyme Regis. In *Dimorphodon* the head is large, the tail is long, and the fifth digit of the hind limb and the tail assist the fore limb in supporting the wing-membrane.

34. Drawing of a long-tailed Pterodactyle, *Rhamphorhynchus muensteri*, natural size; copied from the figure of a nearly complete skeleton from the Lithographic Stone (Kimmeridgian) of Eichstädt, Bavaria, published by O. C. Marsh (American Journal of Science, series 3, xxiii, 1882, pl. 3). The outlines of the wing-membrane are well defined. The long slender tail ends in a leaf-like expansion which clearly served as a steering apparatus. A cast of this specimen is shown in the Geological Department of the Museum.

35. Drawing of *Rhamphorhynchus muensteri* (fig. 10) as restored by O. C. Marsh (l.c. p. 256).

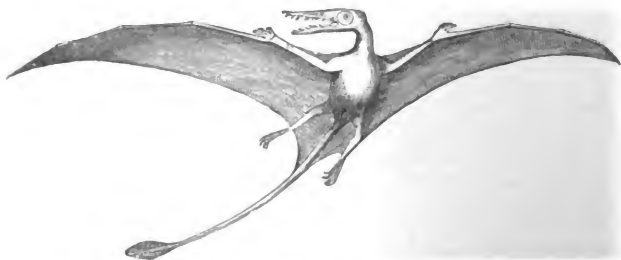


Fig. 10.—Restoration of a Long-Tailed Flying Reptile (*Rhamphorhynchus muensteri*), from the Upper Jurassic (Lithographic Stone) of Eichstädt, Bavaria. One-seventh natural size.

After O. C. Marsh.

36. Cast of the wing of *Rhamphorhynchus gemmingi*, a Pterodactyle from the Lithographic Stone (Kimmeridgian) of Eichstätt, Bavaria. The extent of the wing-membrane is particularly well defined (see frontispiece, upper figure). The specimen of which this is a cast is in the Palaeontological Museum at Munich.

37. Drawing of a small, short-tailed Pterodactyle, *Pterodactylus spectabilis*, natural size; copied from the figure of a complete skeleton from the Lithographic Stone (Kimmeridgian) of Eichstätt, Bavaria, published by H. von Meyer (*Palaeontographica*, vol. x, 1861, pl. 1). A cast of the specimen is shown in the Geological Department of the Museum.

LIZARDS.

38-39. Flying Lizard or Flying Dragon, *Draco spilopterus*. In the various species of *Draco* (e.g. *Draco*

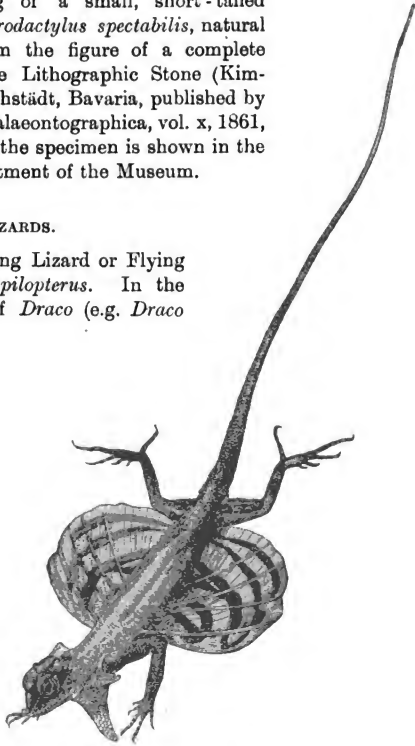


Fig. 11.—A Flying Lizard, or Flying Dragon (*Draco taeniopterus*), showing the fold of skin along the side of the body which enables the animal to glide through the air (see 38).

spilopterus, *D. taeniopterus* (fig. 11), *D. volans*) the skin at the sides of the body is extended to form a patagium, supported by

some of the ribs, which are greatly elongated. The fore and hind limbs remain free. By means of the patagium the Lizards can glide obliquely downward from bough to bough; they cannot fly. In a state of rest the ribs are sloped backward so as to lie up against the sides of the body, and the patagium is thus closed. The species of *Draco* occur mostly in the Malay Peninsula and Archipelago, and the average length is between eight and ten inches. Specimen 38 shows the form of the body with the ribs and membrane fully spread; 39 shows the appearance of the animal when crawling.

40. Skeleton of Flying Lizard, *Draco spilopterus*, showing the remarkable length of the ribs that serve to support the lateral patagial membrane.

41. Flying Gecko (so-called) or Fringed Gecko, *Ptychozoon homalocephalum*. The Fringed Gecko of the Malay countries has lateral expansions of the skin along the sides of the neck, body, tail and limbs, and between the toes, which, it has been suggested, may possibly be used by the animal for breaking its fall when it leaps from bough to bough. In certain other Geckos, however, such as the Bark Geckos, there are similar expansions of skin, but more rough and irregular, and these and the peculiar colour markings on the head and back render the animal difficult to detect as it clings close up against the bark of a tree. The fringes of *Ptychozoon* may perhaps be in like manner cryptic in function (see N. Annandale, *Ann. Mag. Nat. Hist.* (7), xv, 85, 1905, p. 31).

SNAKES.

42. A Flying Snake of Borneo, *Chrysopelea chrysochlora*, in the attitude of descending through the air. Certain arboreal snakes of Borneo, namely, *Chrysopelea ornata*, *Chrysopelea chrysochlora*, and *Dendrophis pictus*, when descending from a height, launch themselves into the air obliquely downward, keeping the body rigid and perfectly straight. On such occasions the transverse section of the body is not circular in outline, but is concave on the under side, owing to a drawing in of the ventral scales by a special muscular contraction (see R. Shelford, *Proc. Zool. Soc.* 1906, pp. 227-230).

AMPHIBIANS.

43. A Flying Frog of Borneo, *Rhacophorus nigropalmatus*, with the fingers and toes spread to display the extensive membrane or web (fig. 12). The various species of so-called

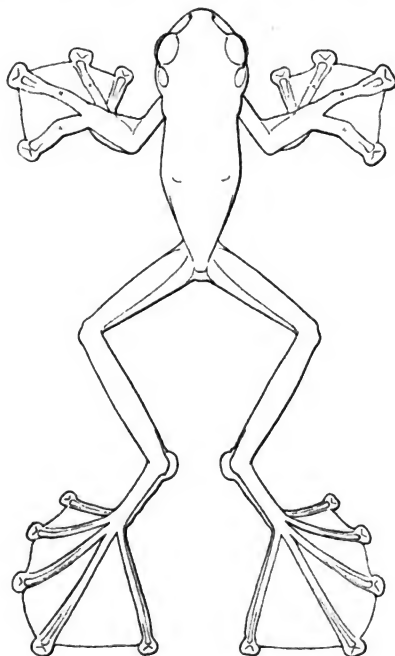


Fig. 12.—Flying Frog (*Rhacophorus nigropalmatus*), with the toes spread to show the membrane, or web, which is present in both fore and hind feet (see 43).

Flying Frog (*Rhacophorus*), although arboreal in habit, and provided with adhesive discs at the extremities of the fingers and toes, are more nearly allied to the Common Frogs (*Rana*) than to the Tree-Frogs (*Hyla*). The fore and hind feet are so broadly webbed in the species exhibited that they have been believed by

some to serve as "planes," enabling the animal to take long flying leaps from branch to branch. The genus *Rhacophorus* is distributed through India and Ceylon, Madagascar, East Indies, China and Japan; the most widely known species are those of Borneo.

FISHES.

44-46. Flying-fish, *Exocoetus*. The various species of Flying-fish (*Exocoetus volitans*, *E. spilopterus* (fig. 13), etc.) are

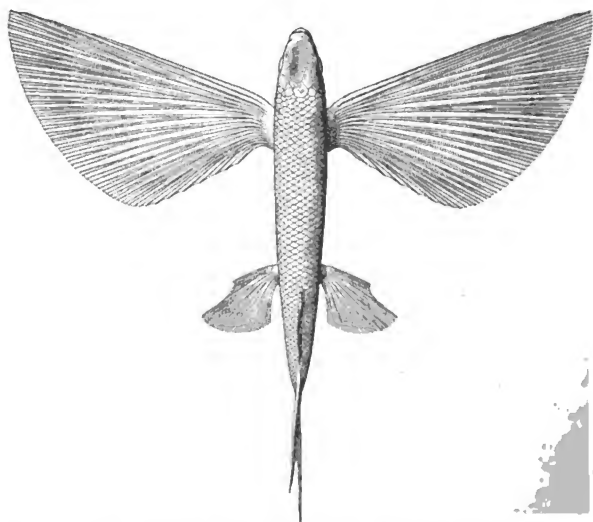


Fig. 13.—A Flying-fish (*Exocoetus spilopterus*), seen from above (see 44-46).

allied to the Skippers and Garfish. They live in shoals in tropical and sub-tropical seas, and are pursued by large fishes such as the Tunny and Albacore.

The question whether Flying-fishes really fly, whether, that is to say, their pectoral fins are moved as organs of flight like the wings of Birds and Bats, is a subject of much contention. Careful observers have recorded the fact that when moving through the

air the fins are agitated, and this may be readily admitted; but while some claim that the fins are flapped like the wings of a Bird, with the definite object of beating the air and propelling the body as well as maintaining it in the air, others regard the rapid movements of the large pectoral fins as like the flapping of a flag waved rapidly through the air.

Two or three hundred yards is no uncommon flight, and although the fishes may rise sufficiently high out of the water to find themselves stranded upon the deck of an ocean-going steamship, Flying-fishes cannot maintain themselves in the air for any considerable period of time, and the probability is that the enlarged fins serve to maintain the body in the air rather than to propel it through the air. The muscles at the base of the pectoral fin are not enlarged in the same proportion as the fin itself, as would be the case if the fins were used as true wings; they are nevertheless considerably larger than the corresponding muscles of allied fishes which have not the pectoral fins enlarged. The initial impetus is provided by the great muscles of the tail; the fishes leave the water with great velocity by a powerful movement of the tail, and move through the air at a rapid rate until they reach the water again, when another lashing movement of the tail may start them afresh through the air without the whole of the body entering the water. The fact that a Flying-fish can change the direction of its course in the air points to the movement being something more than a mere scudding or gliding action.*

The largest species (e.g. *E. californicus*) are about eighteen inches in length. In some species the pelvic fins are enlarged, and evidently assist the pectorals during the movement of the fish through the air; in all species the lower lobe of the tail fin is longer than the upper, a feature clearly correlated with the facility with which the fish darts out of the water.

47. Flying Gurnard, *Dactylopterus volitans* (fig. 14). The various species of *Dactylopterus*, known as Flying Gurnards, have

* For a discussion of the question whether Flying-fishes fly, see:—K. Möbius, *Zeitschr. f. wiss. Zool.* xxx. Suppl. 1878, pp. 343-382; C. O. Whitman, *Amer. Naturalist*, xiv, 1880, pp. 641-653; A. Seitz, *Zool. Jahrb., Abth. Syst.* v, 1890, pp. 361-372; F. Dahl, *Zool. Jahrb., Abth. Syst.* v, 1890, pp. 679-688; F. Ahlborn, *Zool. Jahrb., Abth. Syst.* ix, 1896, pp. 329-338; G. E. H. Barrett-Hamilton, *Ann. Mag. Nat. Hist.* Apr. 1903, pp. 389-393; C. D. Durnford, *Ann. Mag. Nat. Hist.* Jan. 1906, pp. 158-167, and Nov. 1906, pp. 327, 328; P. Rendall, *Zoologist*, Jan. 1912, p. 39; and other papers cited by these authors.

the pectoral fins divided into two parts, the hinder of which is greatly expanded in the adult, and enables the fish to move through the air like the Flying-fish (*Exocoetus*), though for shorter

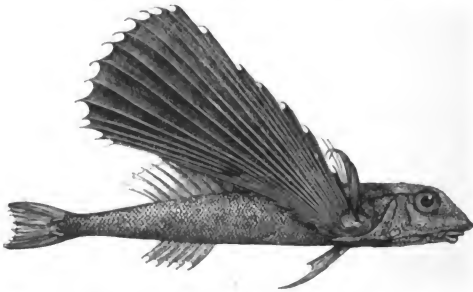


Fig. 14.—Flying Gurnard (*Dactylopterus volitans*) (see 47).
From Günther's *Study of Fishes*, 1880, p. 481.

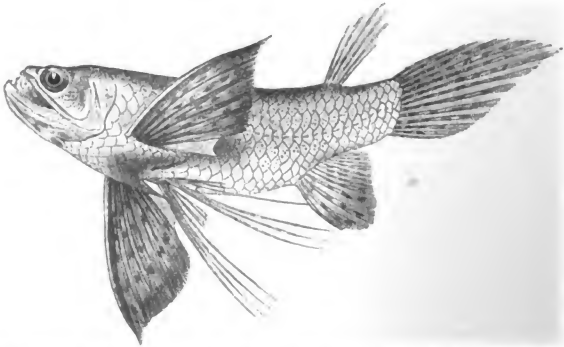


Fig. 15.—An African Fresh-water Flying-fish (*Pantodon buchholzi*) (see 48).
From Boulenger, *Camb. Nat. Hist.* vii, p. 559.

distances.* The Flying Gurnards inhabit tropical and warm seas; the best known is *Dactylopterus volitans*, of the Mediterranean Sea and temperate and tropical parts of the Atlantic Ocean. The largest species are about eighteen inches in length and twenty-four inches in width when fully spread.

* See H. N. Moseley, A Naturalist on the "Challenger," 1879, p. 571.

48. African Fresh-water Flying-fish, *Pantodon buchholzi* (fig. 15). *Pantodon* is a brightly coloured little fish of the Congo and Niger Rivers, which leaps out of the water, and flutters through the air for some little distance before falling back into the river. Of interest in this connection is the fact that the first Congo specimen caught by a European was captured above the water by means of a butterfly net. *Pantodon* is one of the lower Teleostean fishes, belonging to a special family, the Pantodontidae, allied apparently to the Osteoglossidae. The length of the fish is about three or four inches.

49-50. American Fresh-water Flying-fish, *Gastrolepecus*. Several species of *Gastrolepecus* occur in the rivers of British Guiana, and are remarkable for the manner in which they dart out of the water into the air. The fishes are small and laterally

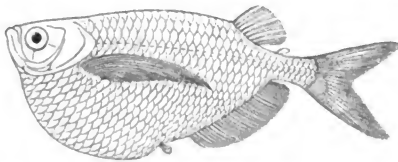


Fig. 16.—A South-American Flying-fish (*Gastrolepecus sternicla*) (see 50).

compressed, and with long and curved, but not particularly large pectoral fins. They dart forward for a distance of forty feet or more, beating the water with their pectoral fins, the upper part of the body alone being exposed, and the sharp keel of the breast acting as a cut-water. They then leave the water entirely for a distance of five or ten feet, and when exhausted fall sideways into the water again.* These fishes belong to the group of the Characinid fishes, which includes the Cariba and Dorado of South America, and the Tiger-fish and Moon-fish of Africa. Two species are shown, *Gastrolepecus strigatus* and *G. sternicla* (fig. 16).

51. *Pegasus volitans*, a little fish found on the sandy shoals of the coasts of Japan, China, India and Australia. The pectoral fins are broad and horizontal, like wings, but so far as locomotion in the air is concerned, the fishes can hardly do more than skim

* See C. H. Eigenmann, Freshwater Fishes of British Guiana, Memoirs of the Carnegie Museum, v, Pittsburgh, 1912, p. 47.

a short distance above the surface of the water.* The dried bodies of these fishes are frequently used by the Chinese, in conjunction with beetles, shells and bits of coral, in the ornamentation of fancy boxes, many of which are brought to England by sailors and travellers as curiosities.

52. Remains of an extinct Flying-fish, *Chirothrix lewisi*. The species of *Chirothrix* (fig. 17) are extinct Teleostean fishes, the remains of which are found in the Upper Cretaceous strata of Mount Lebanon. Their affinities are doubtful, but they are probably

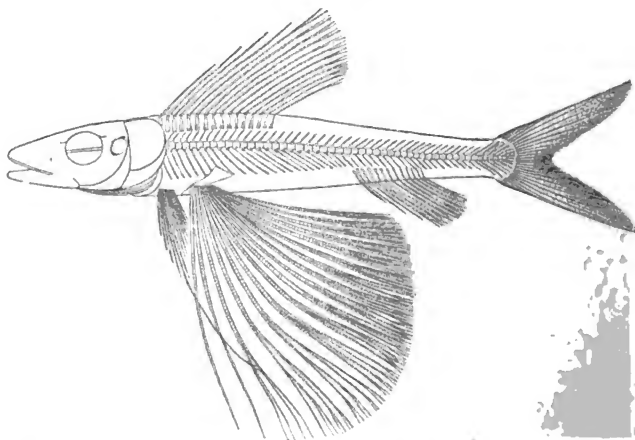


Fig. 17.—Restored Skeleton of a Fossil Flying-fish (*Chirothrix libanicus*), from the Upper Cretaceous of Mount Lebanon (see 52, 53). ($\times \frac{3}{4}$.)

From *Camb. Nat. Hist.* vii, p. 615; after A. Smith Woodward, *Cat. Foss. Fishes*, iv, 1901, p. 281.

related to the Scopelidae. The pelvic fins are of such great size that it has been suggested that the fish employed them for moving through the air, and that it was therefore as much a "Flying Fish" as are *Exocoetus* and *Dactylopterus* at the present day. The determination of the large fins as pelvic rather than pectoral is based upon the structure of the limb-girdles, those parts of the internal skeleton with which the fin-rays articulate. The length

* See F. Day, *Fishes of India*, 1875-78, p. 280.

of the fish is about five inches. Several other extinct fishes have been described as Flying-fish, e.g. *Thoracopterus* and *Gigantopterus* of the Upper Trias of Lower Austria, *Dollopterus* from the Upper Muschelkalk of Jena, and *Erocoetoides* from the Upper Cretaceous of Mount Lebanon.

53. Sketch of restored skeleton of *Chirothrix libanicus*. (Copied from "Cat. Foss. Fishes, Brit. Mus.," iv, 1901, p. 281.)

CASE 2.

BIRDS.

54-55. A Mallard or Wild Duck (*Anas boscas*) mounted in the attitude of flight, and a skeleton of the same species of Bird with the bones arranged as they would be disposed in the flying animal.

In Birds the sheet or layer that beats the air is composed mainly of large feathers, the remiges, which project outward and backward from the fore-arm and hand, and overlap one another in such a manner as to present an almost unbroken layer. The gaps between the quills of these large wing-feathers are closed by smaller feathers, called the wing-coverts (see 56), which also invest the fleshy part of the wing. Along the front edge of the wing there stretches a double fold of skin, the patagial membrane; it extends across the angle between the humerus and the radius, and its free edge is strengthened by a strong elastic cord.

Birds vary greatly in size; some of the Humming Birds rank among the smallest, whereas the largest Birds capable of flight are the Albatros and Condor. The Ostrich is larger than these, and the extinct Moa of New Zealand and the *Aepyornis* of Madagascar were flightless birds of still greater size.

Although the power of flight is very general in Birds, it is by no means universal in the class, several species of different groups having wings too small and weak to raise the body from the ground. In addition to the Ostrich, Moa and *Aepyornis* just mentioned, and the other Ratite Birds—Rhea, Cassowary, Emu and Apteryx—the Dodos (extinct), Penguins, some Auks and Rails, a species of Cormorant and a Parrot, have lost the power of flight. In Penguins, although the wing is useless as an organ of flight, it forms a most efficient paddle for locomotion in the water.

In the skeleton of Birds the chief points to be noticed are the absence of the fourth and fifth digits of the fore limb, and the reduction of the other three digits, there being as a rule only one phalanx in the thumb, and only two and one respectively in the second and third digits. The metacarpal bones of the second and third digits are united at their proximal and at their distal ends (see 79, Gannet). The sternum is provided with a keel of variable dimensions (see 82), this keel being a median plate of bone for the attachment of the great pectoral muscles, which by their contraction cause the beating



Fig. 18.—Right Wing of a Bird, showing the disposition of the feathers (see 56). 1, primary remiges; 2, secondary remiges; 3, major coverts of primaries; 4, major coverts of secondaries; 5, median coverts; 6, minor coverts; 7, marginal coverts; 8, remiges of bastard wing; 9, scapulars.

of the wing. The vertebral column of the tail is shortened up (except in the extinct Bird *Archaeopteryx*, 86), the hindmost vertebrae being fused into a single bone, the pygostyle, to which the large tail-feathers, the rectrices, are attached (see 92-96).

56. Left Wing of a Bird (Mallard or Wild Duck, *Anas boscas*), upper view. In the wing of a Bird the resistance to the air is afforded, not by a continuous membrane as in Bats, Pterodactyles and Insects, but by a series of overlapping feathers, which on the down-beat of the wing are forced together to form an impervious sheet.

Of the large flight feathers of the wing (remiges), those attached

to the bones of the hand are termed "primaries," and those between the wrist and elbow joints are called "secondaries" (fig. 18). The primaries vary in number from nine to twelve, the secondaries from six (Humming-birds and Swifts) to thirty-seven (Albatros).

The basal parts of these flight feathers and the front part of the wing are covered, on both upper and under surfaces, by smaller feathers, "coverts" or "tectrices," disposed in several series, as explained in the preparation here shown. The major coverts are important, in that they close the spaces between the quills of the flight feathers, and thus render the wing as a whole one continuous sheet for resisting air-pressure.

In the autumn Birds usually moult, i.e. shed their feathers, and develop a new set. Birds thus have an advantage over Bats, in that any injury to the feathers is made good in the following season, whereas an injury to the wing-membrane of a Bat reduces the animal's capacity for flight for the rest of its life.

57-58. The principal flight feathers, or remiges, of the wing of a Bird (Mallard or Wild Duck, *Anas boschas*), showing their relations to the bones in the partially closed wing (57), and in the opened wing (58) (frontispiece, lower figure). The feathers that are attached to the bones of the hand (metacarpal and phalangeal bones of the second and third digits) are termed "primaries," those attached to the hinder bone of the fore-arm (ulnar bone) are known as "secondaries." Passing from quill to quill is a ligament which secures an even spacing of the feathers when the wing is opened. In the closed wing the quills of the feathers are set at a sharp angle to the bones of the fore-arm and hand, but as the wing is opened and the angle between the ulnar and metacarpal bones increases, the quills become more widely spaced, and become set more at right angles to the bones to which they are attached. This spreading out of the feathers is a consequence of the mode of linking of the bones of the wing and the mode of connection of the quills by the common ligament. It is independent of muscular action: the feathers can be spread out in a dead bird by merely straightening the skeletal parts of the wing.

59. Dissection of the middle part of the wing of a Bird (Bearded Vulture, *Gypaetus barbatus*), under view, to show the mechanism by which the "secondary" flight feathers are spread. Passing from quill to quill is a common ligament (A) which beyond the wrist is continued on to the quills of the "primary"

feathers (not shown in this dissection). In the closed wing there is but a small angle between the middle and further parts of the wing skeleton (fore-arm and hand respectively), and the secondary feathers make a sharp angle with the fore-arm, and lie close together (see preparations 57 and 58 of the flight feathers of the wing of the Mallard). When the wing is extended, the angle between the hand and the fore-arm opens; the common ligament, acting from the hand, pulls upon the secondary feathers, which being loosely hinged at their bases on the hinder bone of the fore-arm (ulnar bone) spread out, as in the opening of a fan, and stand nearly at right angles to the bone.

Attached to the under side of the quills of the secondary feathers are small tendinous extensions (B) from a muscle (C), a part of the *flexor carpi ulnaris*, which runs the whole length of the fore-arm. During the down-beat of the wing these tendons pull upon the quills, and prevent the whole sheet of flight feathers from being forced up into a vertical position. They do not serve to rotate the quills on their axes, as is sometimes stated.

60-61. Transverse section through the middle part of the wing of a Wood-Pigeon (*Columba palumbus*), including the basal

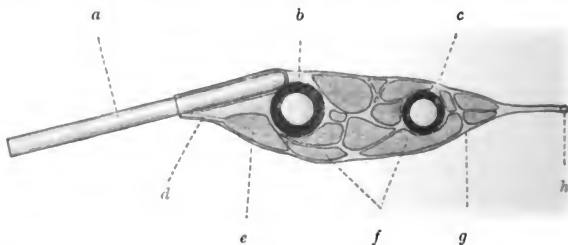


Fig. 19.—Transverse section through the middle part of the wing of a Wood-Pigeon (*Columba palumbus*) (see 60). *a*, quill of feather; *b*, ulna; *c*, radius; *d*, tendon; *e*, *flexor carpi ulnaris*; *f*, other muscles; *g*, skin; *h*, elastic ligament.

part of one of the secondary flight feathers, and an enlarged sketch. The preparation shows how the quill of the feather is supported at its basal extremity on the ulnar bone, and has attached to its under side, near the opening of the quill-pocket, a small tendon which arises from the side of the muscle known as the *flexor carpi ulnaris* (fig. 19). This muscle takes its origin

from the distal end of the humerus, and, after running beneath the ulnar bone for the whole of its length, is inserted by a tendinous extremity into the hinder of the two carpal bones. On contraction, this muscle becomes taut, and prevents the flight feathers from being forced upward by the air-pressure during the down-beat of the wing. It has been claimed, indeed, that the muscle by its contraction actually draws the feathers downward, and thus increases the concavity of the under surface of the wing. For another dissection of this muscle, see wing of the Bearded Vulture, 59.

62. Portions of feather set out in a manner to explain the rotation of the flight feathers which according to some authorities occurs during the up-beat of the wing. The pieces of feather in the upper row illustrate the slant assumed by the feathers when the wing is raised, those in the lower row represent the relations of the feathers during the down-beat of the wing. The flight feathers of the wing, particularly the "secondary" feathers (fig. 18, 2), are capable of a certain rotary or torsional movement about their axes. This movement is automatic, and is not due, as has been stated, to the action of small tendons proceeding from one of the muscles of the wing. During the up-beat of the wing, the broad part of the vane of each feather slopes down and the narrower part of the vane slopes up owing to the air pressure from above being greater on the former than on the latter. The wing thus rises easily through the air. When the wing is forcibly depressed, however, the air pressure being greater on the under side of the broad part of the vane than below the narrow part, the former is pressed up against the narrow part of the vane of the next feather, and the whole system of feathers thus forms an impervious sheet. The slight twist on the axis of the feather which is a necessary accompaniment of the changes above described is well within the limits of torsional elasticity of the axis. The specimens are shown in order to explain the views of certain authorities, but the subject is contentious, and there are those who maintain that the opening and closing of the feathers of the wing like the laths of a Venetian blind cannot take place, because during the up-beat the air cannot get beneath the narrow parts of the feathers to press upon the broad parts of the feathers which they overlap.

63. A flight feather of a Vulture (Bearded Vulture, *Gypaetus barbatus*), namely, one of the secondary feathers of the left wing.

From the main axis barbs project right and left. The proximal and distal edges of the barbs (i.e. towards the basal and apical ends of the feather respectively) bear innumerable barbules, too

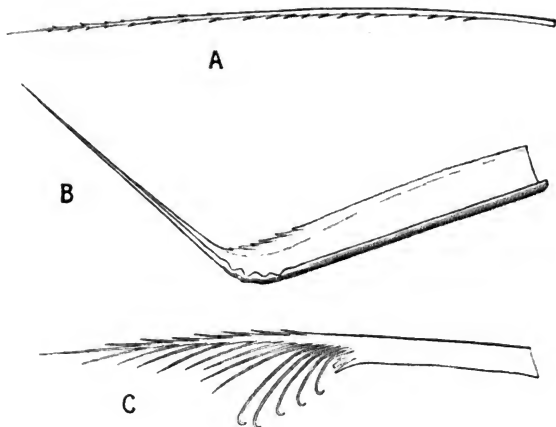


Fig. 20.—A, barbule of a feather of an American Ostrich, enlarged 42 diameters. Small spiny, or hairy, processes occur along the under edge and along a part of the upper edge (see microscope slide M). B, one of the proximal barbules of a wing-feather of a Bearded Vulture, i.e. a barbule taken from the side of a barb that is towards the base of the feather (see 63, C). Enlarged 136 diameters. The basal part of the barbule (towards the right in the figure) has an overturned scroll-like upper edge, the other part is sharply bent upon the basal part, and tapers off to a point. C, one of the distal barbules of a wing-feather of a Bearded Vulture, i.e. a barbule taken from the side of a barb that is towards the tip of the feather (see 63, D). Enlarged 136 diameters. The basal portion of the barbule (towards the right in the figure) is strap-shaped, the other part is broken up or shredded into bristle-like processes, a few of which (five in the specimen figured) end in hooks. These hooks of the distal barbules fasten over the scrolls of the proximal barbules, and thus impart a certain firmness to the vane of the feather (see microscope slide L). The barbule C is represented as flattened out; in the actual specimen the basal half is twisted upon the other half through nearly a right angle (see 63, B and D).

small to be seen by the unaided eye, but illustrated in the sketch A and the model B.

A. Enlarged sketch of the part indicated on the feather by the small square, to explain the position and relative size of the barbs and barbules represented in the greatly enlarged model B.

B. A greatly enlarged model (x 225) of the small portion of the feather indicated in the middle of the sketch A. The basal portions of the *proximal* barbules have scroll-like upper edges, and overlapping lower edges; the free ends of these barbules are very thin, and are bent at an angle to the basal portions, and overlap in planes at right angles to the plane of the feather. The basal portions of the *distal* barbules overlap one another in the plane of the feather; the rest of each barbule, which is at right angles to the basal portion, is cleft or shredded into numerous filaments, of which three, four or five on the under side are strongly incurved. The curved ends hook over the scroll-like upper edges of the proximal barbules—to avoid confusion, the actual hooking is not shown in the model. This locking of the two sets of barbules not only gives a stiffness to the vane of the feather, but also makes it possible for adjacent barbs to become hooked together again after having been forcibly separated. The resistance which the vane of the feather offers to the air is due to the overlapping of the basal portions of the distal barbules, and the overlapping of the lower edges of the basal portions of the proximal barbules.

C. Model of a single barbule of the proximal series, enlarged 225 diameters (fig. 20, B).

D. Model of a single barbule of the distal series, enlarged 225 diameters (fig. 20, C).

64. Feather of a flightless Bird (*Rhea americana*). The fluffiness of the feathers of flightless Birds such as the Ostrich, Rhea and Emu, as contrasted with the firmness of the vane of a feather of a Bird of strong flight, is due to the absence of hooks and scrolls upon the barbules; the barbules, proximal and distal, are all alike and have short spiny or hairy processes along the edges (see microscope slide M, and fig. 20, A). In flying Birds, on the other hand, the proximal and distal barbules are not alike, the former have scroll-like upper edges and the latter have some of the bristle-like projections on the under side ending in hooks. The hooks fasten upon the scrolls, and give to the vane a firmness which enables it to offer considerable resistance to the air (see 63, B; also microscope slide L, and fig. 20, B, C).

65. Dissection of a Bird (Wood-Pigeon, *Columba palumbus*), showing the two principal muscles of flight.

The muscle concerned in the depression of the wing is the *pectoralis major*. In this dissection the *pectoralis major* of the



Fig. 21.—Dissection of a Bird (Wood-Pigeon, *Columba palumbus*), showing the two principal muscles of flight. The right wing is thrown back, and the great breast muscle, the *pectoralis major* (A), has been cut close to its origin from the sternum, and turned aside, so as to expose the deep breast muscle, the *pectoralis secundus*, or *supracoracoideus* (B). The cut edges of the *pectoralis major* are marked C (see 65).

right side (A) has been cut close to its origin from the sternum (see the parts outlined in red), and thrown back so as to expose the *pectoralis secundus*, also known as the *supracoracoideus* (B), the principal muscle concerned in the elevation of the wing (see fig. 21). Compare with this dissection the skeleton of the Pigeon, 67, showing the areas of attachment of the pectoral muscles to the bones.

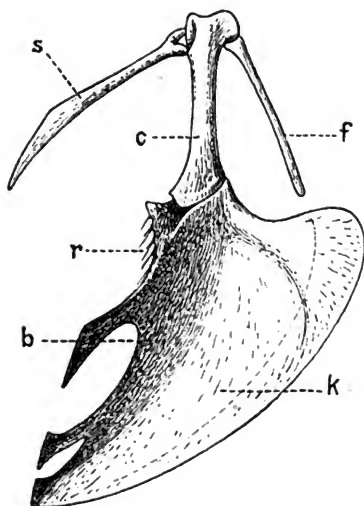


Fig. 22.—Sternum and Shoulder Girdle of a Pigeon (*Columba livia*), seen from the right side. *b*, body of the sternum; *c*, coracoid bone; *f*, furcula or merrythought; *k*, keel of the sternum; *r*, ends of the ribs connected with the edge of the sternum; *s*, scapular bone or shoulder blade.

66. Simple model to illustrate the mechanical principles involved in the elevating and depressing of the wing of a Bird.

The brass lever, representing the wing, is hinged upon a brass frame, the upper piece of which stands for the scapular bone. This piece is held against a board that occupies the position of the middle plane of the body by cords (white cords, representing the *trapezius* and other muscles), in order to suggest that this part of the mechanism can resist a pull but not a push. The stout lower piece (the equivalent of the coracoid bone) presses

D

against a block, but is not fixed to the block; it can resist a push, but not a pull. The third piece, a slender rod representing the clavicular bone, can resist a slight push and a slight pull, and this is suggested by its end being inserted into an eyelet in the board (see skeleton 67, and fig. 22).

The brass lever is actuated by two cords. The blue cord, standing for the *pectoralis secundus* muscle, is attached to the board at a part which may be considered as the equivalent of the keel of the sternum; it passes up between the two lower limbs of the brass framework (as the tendon of the *pectoralis secundus* muscle passes ventral to the coracoid and dorsal to the clavicular bone), it then traverses a guiding hole (*foramen triosseum* of the skeleton), and runs some distance along the grooved upper edge of the lever, and is tied at a point beyond the fulcrum. The red cord, standing for the *pectoralis major* muscle, is attached to the board just below the attachment of the blue cord, and is tied to the lower edge of the brass lever at a point beyond the fulcrum.

If the blue cord be tightened and the red cord slackened the lever rises; if the red cord be tightened and the blue cord slackened the lever is pulled down. The tightening and slackening of the cords find their equivalents in the bird in the contraction (shortening) and relaxation (release from shortening) of the muscles.

67. Skeleton of a Pigeon showing the attachments of the three pectoral muscles. The *pectoralis major* is the principal muscle concerned in the depression of the wing. One part of it (*a*) arises from the lateral portion of the sternum, another part (*b*) from the marginal portion of the keel of the sternum, and the third part (*c*) from the coraco-clavicular membrane and the edge of the clavicular bone. The muscle is inserted into the under side of a process at the front edge of the basal end of the humerus. The *pectoralis secundus* (also known as the *supracoracoideus*), the principal muscle concerned in the elevation of the wing, arises from the sternum, and thins off into a tendon which passes through the *foramen triosseum*, and is inserted into the dorsal side of the basal end of the humerus. The *pectoralis tertius*, a small muscle which draws the wing downward and backward, arises from a small part of the side of the sternum, and from the side of the coracoid bone, and is inserted into the postero-ventral part of the head of the humerus.

68-69. Wings of a Pigeon, *Columba livia*, and a Golden Plover, *Charadrius pluvialis*, dissected to show the relations of two muscles of the fore-arm which are not attached to the bones of the fore-arm, but extend across both elbow and wrist joints.

The *Extensor carpi radialis longior* muscle (E. c. r. l.) arises from the humerus some little distance above the elbow joint. At its distal end it is continued into a tendon which passes along a groove over the end of the radius, and is inserted into the metacarpal bone of the first digit.

Since the elbow and the wrist of a bird flex in opposite directions, the muscle and its tendon are not long enough to admit of the elbow being extended while the wrist is flexed; there follows therefore an automatic action by which the wrist is straightened out when the elbow is straightened.

It may be stated in a general way that when a muscle passes over two joints, as in the present case, it can; without loss of efficiency become converted into a ligament. Although there is no bird in which the e. c. r. l. muscle is tendinous for its whole length, yet in some birds the tendinous part is longer in proportion to the muscular belly than in others—e.g. Plovers, Swifts, Hawks and Owls, as compared with Pigeons and Fowls. That a non-muscular cord would serve the purpose is illustrated by the red cord in model 70.

Among the advantages gained by the conversion of "two-joint" muscles of the limbs into ligaments—perfect examples of which occur in the feet of the Horse and Mole—are the reduction of the weight of the limbs, and a centralising of the muscular tissue within the basal part of the limbs, or even in the body itself. The end joints of the limbs are thus worked by cords actuated by muscles near or in the trunk, and not by muscles situated in the middle parts of the limbs themselves.

A similar but much less efficient instance is afforded by the *Flexor carpi ulnaris* muscle (F. c. u.), which arises from the end of the humerus just beyond the articulation with the ulna, and is inserted into the ulnar carpal bone. For the explanation of its action see the blue cord in model 70. In these dissections the small tendons which pass from the f. c. u. muscle to the quill-pockets (59 and 60, and fig. 19, *d*) have been dissected away.

70. Model of brass and silk explaining the action of the "two-joint" muscles (shown in the dissections 68 and 69), on the

supposition that they have been completely converted into ligamentous cords. When the angle between A (= humerus) and B (= radius and ulna) is opened out, the piece C (= bones of the hand) becomes straightened upon the piece B by the pull of the red cord (representing the *Extensor carpi radialis longior* muscle). When the piece A folds over upon B, the piece C is drawn down by the action of the blue cord (representing the *Flexor carpi ulnaris* muscle).

71. Simple model, constructed of strips of card and drawing-pins, explaining the action of the link-work of the bones of a Bird's wing. The strips are marked "hand," "radius," "ulna," "humerus." When the humerus is moved over to the left, so as to reduce the angle which it makes with the ulna, it pushes the radius to the left and causes the hand to bend down.

72-75. Wings of Gannet, *Sula bassana*, Peregrine Falcon, *Falco peregrinus*, Megapode, *Megapodius nicobaricus*, and Wild Turkey, *Meleagris gallopavo*, to show the differences in shape. In a general way birds of strong and prolonged flight, and birds which remain for long periods on the wing, sparing their energy at times by soaring, have longer and narrower wings than those which are slow and clumsy fliers. Birds which flutter for short distances usually have wings which are roughly as broad as long. Such birds may be very strong fliers for short distances, but they do not remain long in the air. Ordinary migratory birds have wings of intermediate pattern between the two extremes shown.

76-77. Wings of two nearly related Warblers (fig. 23), the migratory Sedge Warbler of Europe (*Acrocephalus phragmitis*) and a non-migratory Warbler of British East Africa (*Cisticola chineana*), and the wings of two Quails, the migratory Common Quail of Europe (*Coturnix coturnix*) and the non-migratory Florida Quail (*Ortyx floridanus*). The generalisation that birds which are good fliers usually have long, pointed wings, whereas poor fliers have blunt-ended or rounded wings (72-75), is of exceptional interest in connection with closely allied species of bird, of which one is migratory in habit whereas the other is sedentary. In the two examples shown the non-migratory bird happens to be larger than the migratory bird, but attention is drawn to the shape, and not to the size of the wings. The wing of the non-migratory bird is rounded at the extremity, whereas

that of the migratory bird is proportionately longer and more pointed. Similar examples might be shown from among the Pigeons, the Thrushes and the Owls.

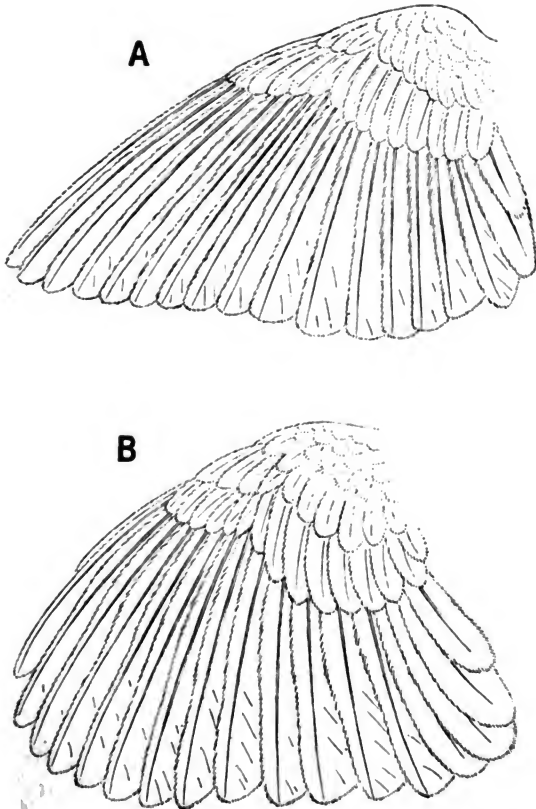


Fig. 23.—Left Wings of a Migratory and non-Migratory Bird, showing the differences in shape. In A (Sedge Warbler, *Acrocephalus phragmitis*, a migratory bird) the wing is comparatively long and pointed; in B (a non-migratory Warbler of British East Africa, *Cisticola chineana*) the end of the wing is rounded (see 76).

78. Diagram showing the relative lengths of the three parts of the wing skeleton in the Gannet, Pigeon and Swift (fig. 24). The wing bones shown in preparation 79 illustrate an interesting

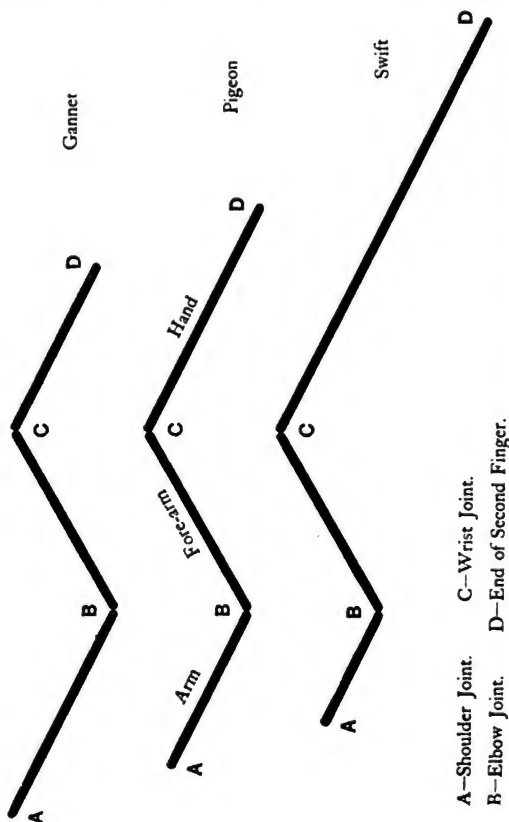


Fig. 24.—Diagram showing the relative lengths of the three parts of the Wing in the Gannet, Pigeon and Swift. (For explanation see 78.)

difference in the proportions of the first, second and third parts of the wing—the arm, fore-arm and hand respectively. The Gannet, Pigeon and Swift are all birds of strong flight, yet in the Gannet

the humerus is longer than the ulna and the ulna longer than the second finger (metacarpal and two phalanges); in the Pigeon the humerus is shorter than the ulna and the ulna shorter than the second digit; in the Swift the humerus is short as compared with the ulna and the hand is remarkably long. Taking the fore-arm as of the same length in all three, the relative lengths of the first part of the wing (from shoulder joint to elbow joint), the second part (from elbow joint to wrist joint), and the third part (beyond the wrist joint) are as represented in the diagram (fig. 24). In the Pelican both the humerus and the hand are shorter than the ulna. In Ratite birds, in which the wing has become reduced, the reduction is much more marked in the fore-arm and hand than in the humerus.

79. Skeleton of the right wings of the Gannet, *Sula bassana*, Pigeon, *Columba livia*, Swift, *Cypselus apus*, Hoatzin, *Opisthocomus hoazin*, and Fulmar Petrel, *Fulmarus glacialis*, showing the differences in the pneumaticity of the bones. In Birds the air-sacs which project from the lungs are continued not only between the viscera, but also to a greater or less extent into the interior of the bones, particularly the sternum, the coracoid and the vertebrae; the air-sacs penetrate to a varying extent into the bones of the wing. Bones so invaded by the air-sacs are said to be "pneumatic." In the Gannet all the bones of the wing are pneumatic; in the Albatros, Swift and Pigeon the humerus is pneumatic, but not the other bones of the wing; in the Fulmar Petrel, Cape Pigeon, Divers, Darters, Cormorants, etc., none of the wing bones are pneumatic. It was formerly stated that the pneumaticity of the bones had the effect of reducing the weight of the bones without reducing their strength, and so served to render the flight of the bird more efficient. As will be seen, however, from the instances mentioned above, the extent of the pneumaticity of the bones is not directly connected with the power of flight, for the birds in question are all strong fliers. On the other hand, the Hoatzin, which scarcely flies at all, but clumsily flutters from tree to tree, has bones which in their pneumaticity agree with those of the Albatros and Swift. And the flightless birds, such as the Ostrich, have bones which in their pneumaticity are not inferior to those of some of the best fliers. In a roughly prepared skeleton of a bird the non-pneumatic bones can usually be distinguished from the pneumatic bones by their yellow colour and greasy appearance.

80. Humerus and ulna of the Albatros, *Diomedea exulans*, cut longitudinally to show the internal cavities. The interior of the humerus is occupied in life by air, that of the ulna is filled with a fatty marrow. Bones of the former kind are termed "pneumatic," those of the latter kind "non-pneumatic" (see 79).

81. Left wing of a Pigeon, *Columba livia*, seen from the under side. The humerus and ulna have been cut open to show the air-sac in the former and the marrow in the latter.

82. Series of sterna and shoulder girdles of fifteen Birds.

The sternum of Birds consists of a bony body or plate, more or less horizontally disposed in the bird as it flies, and a keel, a thin lamella of bone which projects downward from the middle of the plate, and lies in the median plane of the bird's body (fig. 22).

The shoulder girdle consists of a pair of coracoid bones, articulated with the front part of the sternum, a merrythought or furcula, representing a pair of clavicular bones, and thirdly, a pair of shoulder blades or scapular bones, not shown in the majority of the specimens of the present series. The first or basal bone of the wing, the humerus, articulates at the junction of the coracoid and scapula.

The keel of the sternum is relatively most extensive in birds of strong flight, and is wanting in the Apteryx (o), Emu (p), and other flightless birds. These latter, indeed, are termed "Ratitae," because in them the sternum resembles a raft, a flat structure without a keel below. In the Parrot *Stringops* the keel of the sternum is very small.

In some birds, such as the Gannet (κ), Cormorant (c), and Penguin, the keel projects well forward; in the Divers, Cormorant (c) and Gannet (κ), it does not extend on to the hinder part of the plate; in the exceptional Hoatzin (m) the keel is confined to the hinder half of the plate of the sternum. In the Albatros (j), Petrel, Frigate-bird (b), Ostrich and Apteryx (o), the plate or body of the sternum is scarcely longer than it is wide; in Eagles (λ), Geese (π), and Divers it is rather long and parallel-sided; in the Trumpeter (e) and Rail (l), it is much longer than broad; indeed, in the latter the sternum consists of scarcely more than the keel.

In the Pigeons (n) the plate of the sternum is incised behind, and in Game Birds (d), Rails (l) and Tinamous (f) it is deeply incised. The incised regions are in the living bird closed by membrane, and to this as well as to the bony parts the pectoral

muscles are attached; so that an incised sternum does not necessarily signify reduced powers of flight. Of the birds mentioned the Pigeons may be classed as strong fliers, the Game Birds as powerful fliers over short distances, and the Rails and Tinamous as feeble fliers.

The furcula is slender in the Rails (L) and Tinamous (F), but equally so in the Pigeons (X). It is rather weak in both Game Birds (D) and Swifts, but it is thick and strong in the Swans, Screamers and Adjutant (G). In birds of vigorous flight, such as Eagles (A) and Falcons, and birds of powerful sustained flight, such as the Albatros (J), the furcula has its two upper ends wide apart, and it is curved in such a way that in a side view the anterior edge is convex. A similarly curved furcula occurs in the Penguins, which do not fly at all. The furcula is reduced in the Emu, Cassowary and some Parrots; it is wanting in the Apteryx (O), Ostrich and Rhea, and in *Mesites*, a curious thrush-like bird of Madagascar. The hind part of the furcula may for increased steadiness be movably articulated with the front of the keel of the sternum, as in the Gannet (K), or connected with it by ligament, *e.g.* the Adjutant (G), Cormorant (C), Petrel and Albatros (J), or fused with it, as in the Pelican, Crane and Frigate-bird (B). The hind end of the furcula is produced into a hypocleideum in some birds (*e.g.* Game Birds (D)), but this is not united with the sternum. The upper end of the furcula has an articulation with the coracoid in the Pelican, Cormorant (C), Gannet (K), Eagle (A) and Falcon; it is fused with the coracoid in the Frigate-bird (B) and Hoatzin (M).

The coracoid bones are short and broad in the Albatros (J) and Petrels, and have lateral articulations with the sternum in addition to the ordinary articulations. The coracoids are also rather short and broad in the Divers, Eagles (A) and Falcons; they are proportionately long and stout in the Adjutant (G), Pelican, Frigate-bird (B) and Penguin. The sternal ends of the two coracoid bones usually come close together, but they are widely separated in some of the Ratite Birds (O).

On reviewing the skeletal features above recorded it will be seen that there is apparently but little correlation between them and the habits of the birds in question. Different soaring birds do not necessarily agree in the proportions of the sternum and shoulder girdle, and the same may be said of rapid fliers, diving birds, running birds, and birds which turn sharply in the air (such as Frigate-birds and Falcons). One may say that among

allied birds the more powerful fliers have more extensive keels to the sterna than the poor fliers. In birds of strenuous flight, capable of turning rapidly in the air and striking their prey with force, there is usually a concentration of the breast muscles far forwards, and either a lengthening of the coracoids and the sternum, or else a shortening of the coracoids and a widening of the distance between the two ends of the furcula.

Only a few examples of sterna are shown here; a larger collection is to be seen in the South Wall-case in Bay III. of the Entrance Hall.

A. Golden Eagle, *Aquila chrysaetus*. The body of the sternum is parallel-sided. The upper ends of the furcula are wide apart, and are movably articulated with the upper ends of the coracoid bones.

B. Frigate-bird, *Fregata aquila*. The sternum is short and wide. The furcula is fused with the coracoid bones in front and the keel of the sternum below.

C. Cormorant, *Phalacrocorax carbo*. The keel of the sternum projects well forward, and is attached by ligament to the back of the furcula; the keel does not extend over the hinder part of the body of the sternum. The furcula is movably articulated with the upper end of the coracoid.

D. Capercaillie, *Tetrao urogallus*. In the Game Birds the body of the sternum is deeply incised behind. The point of the keel does not reach the level of the front of the body of the sternum. The furcula is produced behind into a process, called the "hypocleideum," but this is not connected with the keel of the sternum.

E. White-winged Trumpeter, *Psophia leucoptera*. The body of the sternum is long, narrow and parallel-sided.

F. Rufescent Tinamou, *Rhynchotus rufescens*. The body of the sternum is deeply incised behind, and the keel is of fair extent. The furcula is greatly reduced.

G. Adjutant, *Leptoptilus dubius*. The sternum is small in comparison with the furcula and coracoid bones. The furcula is connected by ligament with the front of the keel of the sternum.

H. Spur-winged Goose, *Plectropterus gambensis*. The body of the sternum is long and parallel-sided, and fenestrate in its hinder part.

J. Albatros, *Diomedea exulans*. The body of the sternum is wide and short, and the keel not very extensive. The coracoid is short and broad, and articulates with the sternum by two facets.

The furcula is connected with the front of the keel of the sternum by ligament; its upper ends are wide apart.

k. Gannet, *Sula bassana*. The keel of the sternum projects well forward, and is movably articulated with the back of the furcula; the keel does not extend over the hinder part of the body of the sternum. The furcula is movably articulated with the upper end of the coracoid.

l. Clapper Rail, *Rallus longirostris*. The body of the sternum is long and very narrow, and deeply incised behind; the keel is large. The furcula is slender.

m. Hoatzin, *Opisthocomus hoazin*. The Hoatzin, a bird of the Amazon valley, scarcely ever flies, but flutters clumsily from branch to branch and from tree to tree, and is rarely seen on the ground. The sternum is remarkable in that the front part of the keel is absent, a feature correlated with the reduction of the muscles of flight, and partly with the weight of the greatly increased food-pouch or crop. The furcula is Y-shaped, and fused in front with the coracoid and behind with the sternum.

n. Pigeon, *Columba livia*. In Pigeons the body of the sternum is either fenestrate in its hinder part or incised; the keel is large (fig. 22). The furcula is slender, and the upper ends are comparatively close together.

o. Shaw's Apteryx, *Apteryx australis*. The Kiwis, or various species of *Apteryx*, are the smallest of the Ratite Birds, and are restricted to New Zealand. The sternum is broad and without a keel. The sternal ends of the coracoid bones are wide apart. The scapula is fused with the coracoid, and there is no furcula.

p. Emu, *Dromaeus novae-hollandiae* (young). The Emus, or various species of *Dromaeus*, are Ratite Birds of Australia. The sternum is thick and without a keel. The scapula fuses with the coracoid in the adult; there is only a vestige of a furcula.

83-84. Sterna of the migratory Sedge Warbler of Europe (*Acrocephalus phragmitis*) and a non-migratory Warbler of British East Africa (*Cisticola chiniana*). The sternum is relatively larger in the former than in the latter bird, the flight muscles attached to the sternum being more largely developed in the migratory than in the non-migratory species. (The sterna are from the same species as those from which the wings shown in preparation 76 were taken.)

85. Diagrams of the skeleton of the left fore-limb of a Man, a Bat, a Pterodactyle and a Bird, showing that, while the pro-

portions differ considerably, the essential construction of the limb skeleton is the same in all. The humerus is coloured blue, the radius and ulna red, the carpal bones green, and the metacarpal bones and phalanges yellow. Equivalent digits are denoted by similar numerals. (In order to economise space the fifth digit of the Pterodactyle is drawn in the flexed position.) See frontispiece, the upper figure of which is a photograph of the remains of the wing of *Rhamphorhynchus gemmingi* from the Lithographic Stone of Eichstädt, Bavaria, the middle figure a photograph of the wing of a Long-eared Bat, *Plecotus auritus*, the lower figure a photograph of the wing of a Duck, *Anas boscas*, after removal of the smaller feathers, or coverts.

86. Restoration of *Archaeopteryx*; natural size. *Archaeopteryx* is a genus of extinct Birds—the most ancient Birds of which any record is known. Two skeletons, with impressions of feathers, have been obtained from the Lithographic Stone (Kimmeridgian) of Solenhofen, in Bavaria. One of these is in the Geological Department of this Museum, the other is at Berlin. The vertebral axis of the tail of *Archaeopteryx*, instead of being shortened up as in all existing Birds, is long and lizard-like, with the rectrices or principal tail-feathers arranged regularly along the two sides (fig. 25). The bones of the wing and leg differ but little from those of modern Birds; the three digits of the wing end in curved claws. The three digits did not project freely from the front of the wing like the front fingers of a Pterodactyle: many of the published restorations of *Archaeopteryx* are incorrect in this respect. The skull is bird-like in shape and general constitution, but both upper and lower jaws bear teeth.

87. Restored sketch, of the natural size, of the tail of *Archaeopteryx*, showing the relation of the principal tail-feathers (rectrices) to the vertebrae (fig. 25). In *Archaeopteryx* the caudal skeleton is not shortened up as it is in other Birds. The number of caudal vertebrae fused with the sacrum is doubtful, but probably not more than four. Then follow four vertebrae which have short plate-like transverse processes for the attachment of muscles. The remaining vertebrae are fifteen in number, and each supports at its anterior end a pair of the tail-feathers. The last vertebra is long and slender, and lies in the same line with the others; there is no fusion of the terminal vertebrae to form a pygostyle such as occurs in other Birds. In the sketch the principal tail-feathers alone are shown; in all probability the

basal quills of these feathers were covered above and below by small feathers, the tail-coverts, but there is no evidence of them in the fossil remains at present known. In contrast with the large number (15 pairs) of tail-feathers in *Archaeopteryx* it is to be noted that in modern Birds the usual number of rectrices is six pairs; the Common Snipe, however, has seven pairs, and the Great Snipe eight pairs, while in *Gallinago stenura* there are as many as ten pairs.

88-89. Tails of Wood-Pigeon, *Columba palumbus*, showing the principal feathers (rectrices) closed and spread. The quills of the rectrices arise close together at the sides of the ploughshare bone or pygostyle, and not at intervals along the sides of a vertebral axis as in *Archaeopteryx* (fig. 25). The feathers, therefore, while setting more or less parallel when the tail is closed, radiate when the tail is opened.

90. Dissection of the pelvis and tail of a Pigeon, *Columba livia*, showing the two muscles which are principally concerned in the opening out of the rectrices or large feathers of the tail. The muscle seen on the right side at *A* is the *pubi-coccygeus*, also known as the *adductor caudae*. It arises from the hinder part of the pubic bone, and is inserted into the sheath of the outermost tail-feather. On the contraction of the muscle this feather is drawn downward and outward, and the other feathers (excepting the innermost) follow, being connected by an elastic ligament at the mouths of the quill-sheaths. The muscle seen on the left at *B* is the *levator coccygis*, also known as the *levator caudae*. Its effect, on contraction, is to draw the basal end of the outermost feather upward, forward and inward. The upward pull counteracts the downward pull of the *pubi-coccygeus* muscle. The forward and

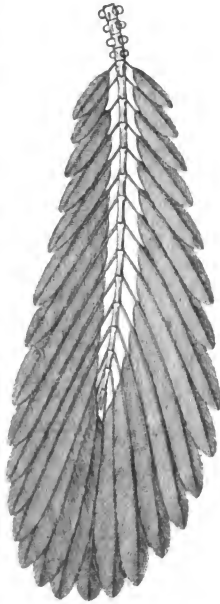


Fig. 25. — Tail of *Archaeopteryx*, showing the relation of the principal feathers (rectrices) to the vertebrae. The small covering feathers (coverts) are not shown (see 87).

inward pull on the basal end of the outer feather has the effect of directing this and the adjoining feathers somewhat outward. Compare with this dissection model 91.

91. Simple model to illustrate the mode of opening and closing of the tail of a Bird. The tail consists usually of six principal feathers on each side of the middle plane. The basal ends of the feathers are held together by connective tissue in such a manner that, while a certain amount of radiating movement is possible, the bases of the feathers do not separate. This is suggested in the model by the card strips (representing the quills of the feathers) being pinned in a movable manner upon a short strip of wood. The strip of wood is movably pinned at the end near the red line, but is otherwise free. At some distance along the strips of card from their pinned ends a piece of elastic passes across the series, and is stitched to each by a green thread. This piece of elastic is the equivalent of the elastic ligament which in the bird passes from quill to quill, and secures the even spacing of the feathers when the tail is opened. The piece of elastic is fixed at the inner end (near the red line), but at the outer end is tied to a blue cord, which passes outward and upward (*i.e.* forward in the bird) and is tied to a brass eyelet. When the blue cord is tightened, the elastic stretches, the strips of card open out in a radiating manner, and the strip of wood to which the cards are movably pinned moves round. When the blue cord is slackened, the elastic shortens, the card strips close up and are drawn parallel to the red line. The tightening and slackening of the blue cord represent the contraction and relaxation of the *pubi-coccygeus* and *levator coccygis* muscles of the bird, which are attached to the sheaths of the outermost feathers of the tail, and pass forward to be attached to parts of the skeleton. See dissection 90.

92. The hindermost portion of the vertebral column and the pelvic girdle of a Wood-Pigeon, *Columba palumbus*, seen from the dorsal aspect. In Birds the mass of fused vertebrae constituting the sacrum (or synsacrum) is exceptionally large. The number of vertebrae included varies in different birds; in the present instance there are fourteen vertebrae, consisting of the last thoracic, the lumbar and sacral vertebrae and some caudal vertebrae. The next six caudal vertebrae are free and movable, and the series is terminated by an uptilted bone known as the pygostyle, which represents a number of coalesced vertebrae.

It is to the right and left sides of the crest of the pygostyle that the innermost pair of tail-feathers are attached.

93. The hinder portion of the vertebral column, and the pelvic girdle, of a young Fowl, two days after hatching. Under side.

94. An enlarged sketch of the last twelve elements of the vertebral column of a young Fowl, two days after hatching (93). The four vertebrae marked A become the free or movable caudal vertebrae of the adult, the last six elements (B) fuse up to form the pygostyle.

95. The last five pieces of the vertebral column of an adult Fowl. Left side. A, the four free caudal vertebrae; B, the plough-share bone or pygostyle, formed by the fusion of six bones which are separate in the young. (In some individuals there are five free caudal vertebrae, and the pygostyle then includes five bones only.)

96. The last five pieces of the vertebral column of a younger Fowl, showing the component parts of the pygostyle not yet completely fused. Left side.

INVERTEBRATES OTHER THAN INSECTS.

It is worthy of remark that the only animals that really fly are either Vertebrates or Insects. The only Invertebrates other than Insects that are of interest in the present connection are the Parachuting Spider, the young spiders of many species that float about by means of their gossamer threads, and the so-called Flying Copepods.

97. Enlarged drawing of the Parachuting Spider, *Saitis volans* (*Attus volans*), of New South Wales (fig. 26). This spider is a small jumping spider, with the lateral edges of the abdomen expanded into plates which, by acting as a parachute, enable the animal to take exceptionally long leaps. When at rest the



Fig. 26.—The Parachuting Spider, *Saitis volans* (*Attus volans*), of New South Wales. The spider is one-sixth of an inch in length.

From O. P. Cambridge, "On some new Genera and Species of Araneidea," *Ann. Mag. Nat. Hist.*, ser. 4, vol. xiv, No. 81, 1874, pl. XVII, fig. 4.

lateral flaps are bent downward. The spider is rare, and only males are known.

98. A Spider, *Celaenia excavata*, female, with its cocoons, and the young spiders removed from one of the cocoons. In this and most spiders the young, on hatching out in the summer and autumn, resort to a "ballooning" habit which secures their dispersal far and wide. The young spider climbs to the top of a stalk and faces the wind. Raising the body by stiffening its legs, it exudes one or more fine threads (gossamer threads) from the spinnerets at the end of the abdomen and allows them to float away freely into the air (fig. 27, A). When the threads are sufficiently long the spider lets go its grip, and is carried away by the wind. It floats passively, with its upper side undermost (fig. 27, B, C), until a suitable stopping-place is reached. The descent is then controlled by the spider gathering in the filaments with its front legs and rolling them up on the under side of the body (fig. 27, D)

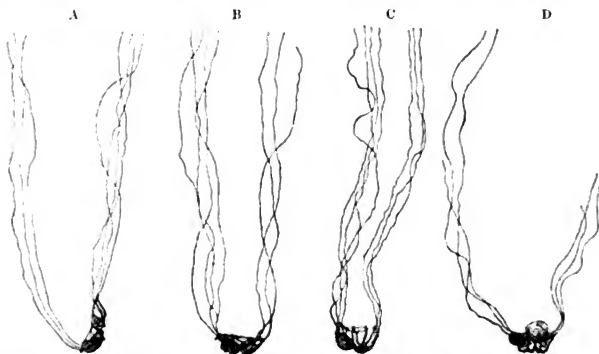


Fig. 27.—Enlarged sketches of young Lycosid Spiders floating by means of their gossamer threads. A, attitude of the spider just after taking flight; B and C, attitude when floating in the breeze; D, attitude of the young spider gathering in its threads for descent.

From H. C. McCook, *American Spiders*, vol. ii, 1890, pp. 260, 261.

until the general buoyancy is lessened, enabling the spider to float down to the ground in the selected area. More often, however, the spider is brought up by contact with the foliage of a tree. The speed of the "flight" is of course determined by the force of the wind, and the distance covered is inversely as the amount of

obstruction encountered.* Sometimes the several threads of the same spider or the threads of several spiders become entangled into a flocculent mass or "mop," which is blown through the air until the young spiders decide to alight, when they hang down from the "mop" by single threads and separate themselves from it.

99. Enlarged sketches of young Lycosid Spiders floating by means of their gossamer threads (fig. 27).

100. Flying Copepods, *Anomalocera patersoni*, and an enlarged sketch. At least three forms of oceanic Copepod Crustacea † have been described as "Flying Copepods." They cannot, however, do more than spring out of the water and fall back again. They are of small size ($\frac{1}{8}$ inch in length), and occur in great swarms. In calm weather frequently the surface of the sea appears disturbed, as if by fine rain, owing to the emergence and re-entry of these crustaceans. In structure the Flying Copepods do not differ materially from others which have not the habit of springing into the air.

CASE 3.

INSECTS.

The wings of Insects are outgrowths from the second and third segments of the middle part of the body (thorax), and arise between the edge of the back (notum) and the side wall (pleuron) of the body (see diagram 108). They consist of two layers of very thin skin covered with the hard flexible substance (chitin) that forms the outer shell of the body of Insects, and between these two layers of the wing there run tracheal tubes for breathing and fine blood-vessels. The soft hinge membrane at the base of the wing may include a number of small pieces of hard chitin, which render the hinge-joint very complex.

No Insect has more than two pairs of wings.‡ In some

* A detailed account of the dispersal of young spiders by means of their gossamer threads is given by H. C. McCook, "American Spiders and their Spinningwork," vol. ii, Philadelphia, 1890, pp. 256-282.

† *Pontella atlantica*, *Pontellina mediterranea*, *Anomalocera patersoni*.

‡ Certain extinct Insects from the Carboniferous formation had flattened movable outgrowths like small wings projecting from the first segment of the thorax, and some modern Moths (e.g. the Owl Moths) have some movable plates, known as the patagia, attached to the "collar," or reduced prothoracic ring.

Insects (*e.g.* Beetles) the front pair are hardened and are not used for flight, but act as protective coverings for the second pair when the Insect is not flying. In some other Insects (*e.g.* Flies) the second pair of wings are reduced to small, stalked balancers or poisers (halteres). In others, again (*e.g.* Fleas and Spring-tails), both pairs of wings are wanting.

While the wings of Birds, Bats and Pterodactyles are the pectoral limbs modified for purposes of flight, the wings of Insects are not modified limbs, but are outgrowths of the dorsal plates (tergites) having no connection with the legs.

101. The front wings of a Moth (Emperor Silk-Moth, *Attacus vesta*) prepared to show that the wing of an Insect is composed of two separable layers. The left wing has been completely divided into its two component layers, the right wing is only partially split.

102. An American Locust, *Dissosteira carolina*, together with an enlarged sketch of the right fore and hind wings showing the complexity of the hinge-system.

WING MUSCLES OF INSECTS.

In Insects the muscles which move the wings are very numerous and complicated, and in the series of specimens here exhibited the muscles which are concerned with the straightening out, the folding up, the drawing forward, the drawing backward, and the alteration of the antero-posterior slope of the wing are disregarded, and only the larger muscles, those concerned with the elevation and depression of the wing, are illustrated and explained. The elevator and depressor muscles are of two kinds, direct and indirect. In the Dragon-flies the direct muscles are the principal muscles concerned, in Locusts and most Orthoptera the direct and indirect muscles are equally developed, but in most Insects (Beetles, Butterflies, Flies, Wasps, etc.) the direct muscles are feebly developed, and the indirect muscles are the largest in the whole body.

DIRECT MUSCLES OF THE WINGS OF INSECTS.

The direct muscles which raise the wings and those which depress them are vertically disposed muscles, attached at their lower ends to the sternal (lower) portion of the exoskeleton, near the

bases of the legs, and attached at their upper ends to the bases of the wings, or to small separate hard parts close to the bases of the wings. The hinge of the wing upon the body is extremely complex in structure, but from a mechanical point of view there can be recognised what is practically a single fulcrum. The elevator muscle is connected with the very short arm of the lever on the internal side of the fulcrum, *i.e.*, on the side nearer the middle of the body; the depressor muscle is connected with the long external arm of the lever (the wing itself), close up to the fulcrum. The mechanical principles involved are explained in model 103. The direct muscles of the wings are well developed in the Libellulidae (Dragon-flies), moderately developed in the Orthoptera, and only feebly developed or wanting in most Insects.

103. Flight Mechanism of Insects (Direct Action).—Simple model to illustrate the mechanical principles involved in the elevating and depressing of the wing of an Insect by the action of the direct muscles.

The brass lever, representing the wing, is hinged upon a curved piece of steel clock-spring which stands for the outer casing (chitinous exoskeleton) of the body of the Insect. The lever is actuated by two cords. The blue cord, standing for the direct elevator muscle, is attached to the lower part of the clock-spring (the part coloured green, and representing the sternum of the Insect); the upper end of the cord is tied to the lever at its inner end, that is, at a point nearer to the board than the fulcrum. The red cord, standing for the direct depressor muscle, is attached to the lower part of the clock-spring, and at its upper end is tied to the lever slightly beyond the fulcrum. When the blue cord is tightened and the red cord slackened, the lever rises; when the red cord is tightened and the blue cord slackened, the lever is drawn down.

INDIRECT MUSCLES OF THE WINGS OF INSECTS.

The indirect muscles which raise and depress the wings are not immediately connected with the wings, but are attached at both ends to the exoskeleton of the thorax, which being flexible can be altered in shape by their contraction, and in consequence of the change of curvature the wing is raised or lowered. The depressor muscle is disposed longitudinally in the body, and is attached at both fore and hind ends to downward continuations of the notum, or dorsal part of the exoskeleton, of the particular

somite (either the second or third thoracic) to which the wings belong. When the downwardly directed plates are approximated by the contraction of the great muscle which connects them, the notum above this muscle becomes more convex, and thus rises in its middle part. The rising of the middle part of the notum lifts the short inner arm of the lever, which has its virtual fulcrum at the junction of the notal (back) and pleural (side) portions of the exoskeleton; the long arm of the lever, the wing itself, is consequently lowered.

The elevator muscle runs vertically, or nearly so, and connects the notal (upper) and sternal (under) portions of the exoskeleton; and, since the sternum is more rigid than the notum, the contraction of the muscle has the effect of flattening the latter. The drawing down of the middle part of the length of the notum depresses the short arm of the lever, and consequently raises the long arm, or wing itself.

The mechanical principles involved are explained in model 104.

The indirect muscles are well developed in most Insects; they are moderately developed in Orthoptera, and very feebly developed or wanting in the Dragon-flies.

104. Flight Mechanism of Insects (Indirect Action).—Simple model to illustrate the mechanical principles involved in the elevating and depressing of the wing of an Insect by the action of the indirect muscles.

The brass lever, representing the wing, is hinged upon the upper end of the rigid part of the model, coloured yellow and green, and representing the pleuron and sternum respectively of the exoskeleton of the Insect. The curved piece of clock-spring (representing the notum of the Insect) fits at its edge into a notch in the short arm of the lever, and while free from the board (representing the middle plane of the body), works upon a guiding rod that is firmly attached at its middle to the yellow piece.

The lever is actuated by two cords, neither of which is tied to the lever. The blue cord is attached below to the rigid green piece and at its upper end to the middle of the clock-spring. The red cord is attached at its ends to the descending parts of the clock-spring. When the red cord is tightened and the blue cord slackened, the clock-spring becomes more curved, its upper, middle part is raised, the short arm of the lever is consequently raised, and the long arm is lowered. When the blue cord is tightened and the red cord slackened, the upper middle part of

the clock-spring is drawn down, the short arm of the lever also is drawn down, and the long arm rises.

105. Dissection of a Dragon-fly, *Aeschna cyanea*, with the side wall of the thorax removed to show the chief muscles of the wings. Of the four muscles seen the first and third draw the two

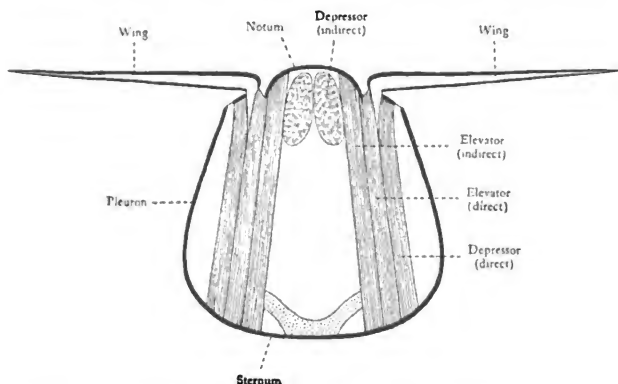


Fig. 28.—Diagrammatic sketch of a section across the thorax of a Locust, showing the principal muscles concerned in the elevation and depression of the wings (see 108).

wings forward, the second and fourth draw them downward. The elevator muscles lie deeper, and are not shown in the dissection.

106. Dissection of a Goliath-Beetle, *Goliathus giganteus*, with all the internal parts removed except the muscles of the wings. In the upper dissection the indirect elevator muscle of the wing is seen extending horizontally between two vertical skeletal plates projecting downward from the back (notum). In the lower dissection the indirect elevator muscle has been removed, and the vertically disposed indirect depressor muscle of the wing is seen extending from the notum to the sternum. The lower part of the indirect elevator muscle is also seen in the upper dissection. Small direct elevator and depressor muscles of the wing are present in Beetles, but in these dissections they are concealed from view by the great indirect muscles.

107. Dissection of a Locust, with the hind thoracic segment (metathorax), together with the second pair of wings and the third pair of legs, separated from the rest of the body, and showing the principal muscles of the wing. See explanatory sketch 108.

108. Diagrammatic sketch of a transverse section through the metathorax of a Locust, showing the four principal muscles of the wings (see fig. 28).

CHARACTERISTICS OF THE WINGS IN THE DIFFERENT ORDERS OF INSECTS.

BUTTERFLIES AND MOTHS (LEPIDOPTERA).

In Lepidopterous Insects both the front and hind wings are developed as organs of flight, and they are invested with closely disposed minute scales which give a fur-like or velvety appearance to the surface.

109. A Hawk-Moth, *Pseudosphinx tetrio*, after removal of the scales from the wings of the left side. The wing-membrane so prepared is as clear and its venation as distinct as in the wings of Flies and Dragon-flies.

110. An enlarged sketch ($\times 150$) of three scales removed from the same Moth. The scales are flat, with longitudinal striations; they are attached to the surface of the wing by a kind of short stalk, while the free edge of the scale is broad and toothed. See slides F, G and H under the microscope, and fig. 42.

111-112. Two Clear-wing Hawk-Moths, a British species, *Hemaris (Haemorrhagia) fuciformis*, and a South African form, *Cephonodes hylas*. In Clear-wing Moths the scales of the wings resemble those of other Moths at the time that the insect emerges from the pupa-case, but they are fugitive, and most of them are shaken off during the first few flights.

113-114. Male and female of a large Butterfly, *Troides (Ornithoptera) priamus urvillianus*, from the Solomon Isles. The male is brightly coloured, while the female is dull. The female is a slower flier than the male, and has a larger expanse of wing; this is doubtless related to the fact that the female is weighed down by the mass of unlaidd eggs in the body.

115-116. A Moth, *Urania leilus*, and a Butterfly, *Papilio policles*, in which the hind wings are produced backward and outward into "tails." It is not clear what effect such prolongation of the wings may have upon the flight of the insects, but it is

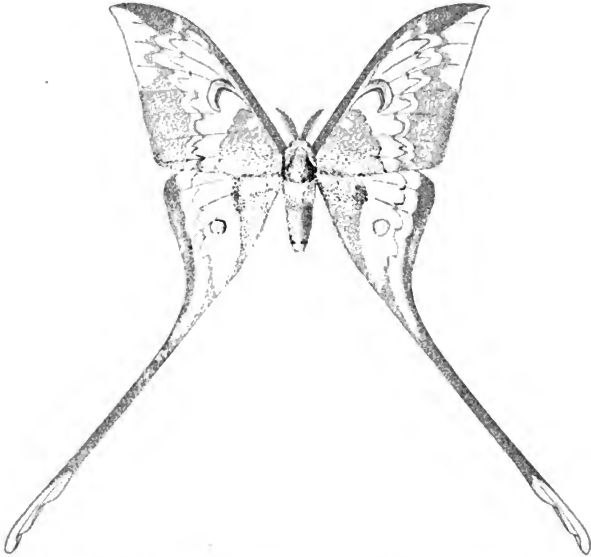


Fig. 29.—*Actias maenas*, an Indian Moth of the family Saturniidae. The hind wings are prolonged backward into long balancers (see 115).

interesting to note that the same form of "tail" has been independently evolved in Moths and Butterflies.

In some Lepidoptera of the family Saturniidae (e.g. *Actias*, fig. 29, *Eudaemonia* and *Copiopteryx*), and of the families Zygaenidae (e.g. *Himantopterus*), Lycaenidae and Hesperidae, the hind wings are drawn out into long thread-like or lamellar balancers with roughly spiral or wrinkled leaf-like ends, almost exactly like the hind wings of the Nemopterous Neuroptera (e.g. *Halter* and *Kirbynia*, fig. 33). These balancers do not participate in the flapping of the wings, but trail behind in a passive manner.

An explanation that has been offered is that the "tails" have a protective value and enable the Moth to escape from a predatory Bird with the loss of the ends only. This is perhaps supported by the presence in some Moths of an enlarged extremity to the "tail" with a special mark, the "directing mark."

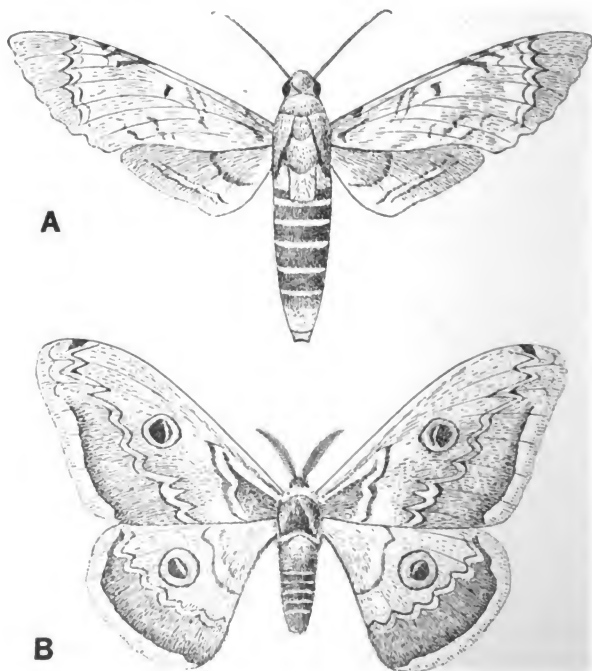


Fig. 30.—A, a rapidly flying Moth (*Pseudosphinx tetrio*), and B, a slowly flying Moth (*Saturnia pavonia-major*), showing the differences in the shapes of the wings and in their superficial area (see 119–120).

117–118. Owl Moth, *Noctua strix*, South America, and Atlas Moth, *Attacus atlas*, India. These species of Moths are among the largest Lepidopterous Insects known; they attain a greater size than the specimens here shown. Such Moths are not,

however, by any means the largest flying insects on record, for some of the extinct Dragon-flies of the Carboniferous Period measured two feet across the wings. See outline sketch of *Meganeura monyi*, 127, on the back of Case 3.

119-121. A rapidly flying Moth, *Pseudosphinx tetrio*, and a slowly flying Moth, *Saturnia pavonia-major* (fig. 30, A and B). Also a Burnet Moth, *Zygaena filipendulae*. Among the Lepidoptera the most rapid and powerful fliers have longer and narrower wings, with a straighter front edge, than the more leisurely and feeble fliers. They not only move through the air at a higher speed, but the rate of flapping of the wings is also greater than in the case of more slowly travelling Butterflies and Moths. The Burnet Moths might in a way be regarded as exceptions, for they fly about lazily and yet have rather long, narrow front wings.

122. Left front and hind wings of a male Hawk-Moth, *Pseudosphinx tetrio*, seen from below, showing the frenulum and

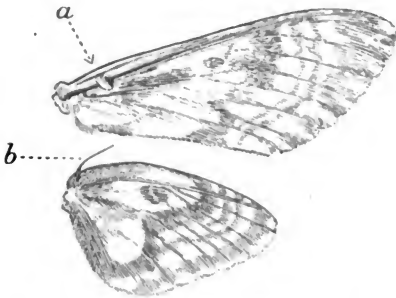


Fig. 31.—Left front and hind wings of a Death's-head Moth (*Acherontia atropos*), seen from below, showing the retinaculum (a) and the frenulum (b) (see 122).

retinaculum. In Lepidoptera the front wing overlaps the hind wing, so that in flight the two wings of the same side must act in co-ordination. In most Moths, but not in Butterflies, this co-ordination is secured by a frenulum, which projects from the front edge (costa) of the hind wing, and is secured into a retinaculum situated on the under side of the front wing, near the base. In the large majority of Moths the retinaculum descends

from the costal nervure in the male, while in the female it ascends from the median nervure. In the female the frenulum consists in most cases of three separate bristles, but in the male it is a composite structure usually in the form of a single curved bristle. See microscope slides D and E, and fig. 31. In the Orders of Insects other than the Lepidoptera the hind wing is secured to the front wing of the same side of the body by other means; see the labels referring to the Hymenoptera and Hemiptera.

123. Left front and hind wings of a Ghost-Moth, *Hepialus humuli*, after removal of the scales, showing the jugum. In a few Moths (the Hepialidae, or Ghost-Moths, and the Micropterygidae) there is no frenulum, but a small lobe, the jugum, projects from the base of the hind edge of the front wing towards the hind wing, and may serve to secure a feeble connection between the two wings of the same side.

DRAGON-FLIES, ETC. (NEUROPTERA).

In most Neuropterous Insects both front and hind wings are used for flight; they are clear and transparent and have a net-like venation. They are approximately equal in size in Dragon-flies, Ant-lions and Lace-wings (fig. 32), but in the May-flies (fig. 32) the hind wings are small. In the Nemopteridae (e.g. *Kirbynia* and *Halter*, fig. 33) the second pair of wings are in the form of long balancers. The Neuroptera include some of the largest Insects known (see 127).

124. An American Dragon-fly, *Megistogaster lucretia*. The front and hind wings are of the same size.

125. *Kirbynia sheppardi* (fig. 33), a Neuropterous Insect of the family Nemopteridae. The hind wings are in the form of long balancers. In some Nemopteridae, e.g. *Halter imperatrix*, the balancers are longer and more slender (fig. 33, lower figure).

126. May-fly, *Ephemera vulgata* (fig. 32). The hind wings are much smaller than the front wings.

127. (In frame on the back of Case 3). Outline sketch, of the natural size, of *Meganeura monyi*, one of the giant Dragon-flies of the Coal Measures of Commeny, France. The span of the wings measures a little over two feet. (Figure copied from C. Brongniart, "Insectes fossiles des temps primaires," 1893, Atlas, Plate 43.)

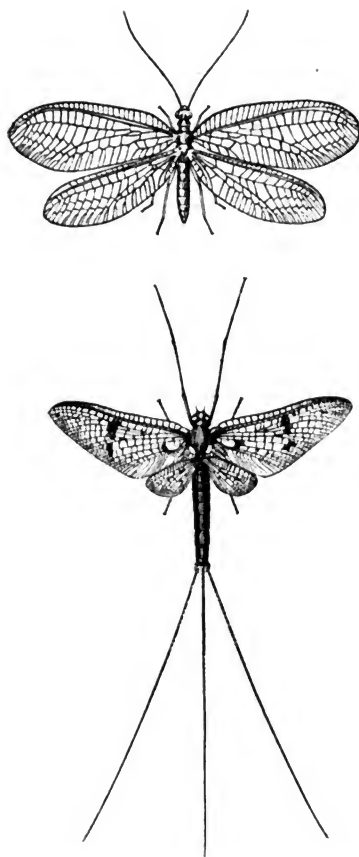


Fig. 32.—Neuropterous Insects—Lace-wing (*Chrysopa perla*) and May-fly (*Ephemera vulgata*). In the Lace-wing (upper figure) the hind wings are only slightly smaller than the front wings; in the May-fly (lower figure) they are considerably smaller (see 126).

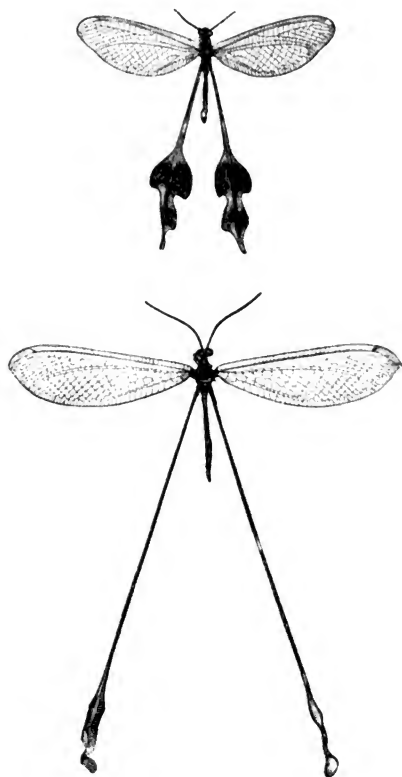


Fig. 33.—Neuropterous Insects of the family Nemopteridae—*Kirbynthia shepardi* (upper figure) and *Halter imperatrix* (lower figure). The hind wings are modified into balancers, and do not beat the air during flight (see 125).

WASPS, BEES, ANTS, ETC. (HYMENOPTERA).

In Hymenopterous Insects the wings are four in number; they are membranous, and usually transparent. Both front and hind pairs are used for flight (except in wingless worker Ants, etc.),

and the hind pair are smaller than the front pair. In Wasps and Bees the two wings of the same side move as one structure owing to a series of small upwardly directed hooks on the front margin of the hind wing fitting over a downwardly projecting ledge on the hind margin of the front wing. See slide A shown under the microscope, and fig. 41.

128-130. A Hornet, *Vespa crabro*, an Ichneumon, *Ephialtes manifestator*, and a Saw-fly, *Sirix gigas*, as examples of Hymenopterous Insects.

BEETLES (COLEOPTERA).

In Coleopterous Insects the second pair of wings alone are organs of flight, the first pair being modified into hard, shell-like structures (elytra), beneath which the functional wings can be folded up. In some Beetles (*e.g.* Stag-Beetle and *Macrotoma*) the elytra are lifted up during flight, and in consequence of their concavo-convex shape they may be of some value in maintaining the body in the air. In other Beetles the elytra are during flight only raised sufficiently to allow of the emergence of the wings below their outer edges (*e.g.* Goliath-Beetle, Rose-Beetle).

131-132. Examples of Beetles which raise the elytra during flight—Stag-Beetle, *Lucanus cervus*, Europe, and *Macrotoma coelaspis*, Tropical and South Africa.

133-134. Examples of Beetles which during flight raise the elytra only sufficiently for the emergence of the wings—Goliath-Beetle, *Goliathus giganteus*, Tropical Africa, and a Chinese Rose-Beetle, *Protaetia speculifer*.

FLIES (DIPTERA).

Dipterous Insects, or Flies, have only the first pair of wings developed as organs of flight (fig. 34); the second pair are reduced to small stalked balancers or "halteres" (fig. 43). For the structure and relations of these last see the enlarged models of House-Fly, Tsetse-Fly and Mosquito in the middle of the Hall.

The halteres are characteristic of the Diptera, though they are absent in most of the wingless forms of the order. The halter in most cases resembles a pin, being a slender rod with an

enlarged rounded head, but the form of the head varies considerably. The function of the halteres is not clear; the most



Fig. 34.—A Horse-Fly (*Tabanus bovinus*). Nat. size.

probable assumption is that they act as sense organs. Each is provided at its base with muscles, and can, like the wings, execute rapid vibrations. Since the halteres are the homologues of wings, it is remarkable that in none of the Diptera are they represented by wings or by structures intermediate in character between balancers and wings.

135–137. An African Horse-Fly, *Tabanus ruficrus*; a British Mosquito or Gnat, *Theobaldia fumipennis*; and a large South American Fly, *Pantophthalmus championi*; as examples of Dipterous Insects.

LOCUSTS, COCKROACHES, ETC. (ORTHOPTERA).

In most of the Orthoptera (*e.g.* Locust, fig. 35) the front pair of wings (tegmina) are stiffer than the second pair, and protect the latter when the insect is not flying.

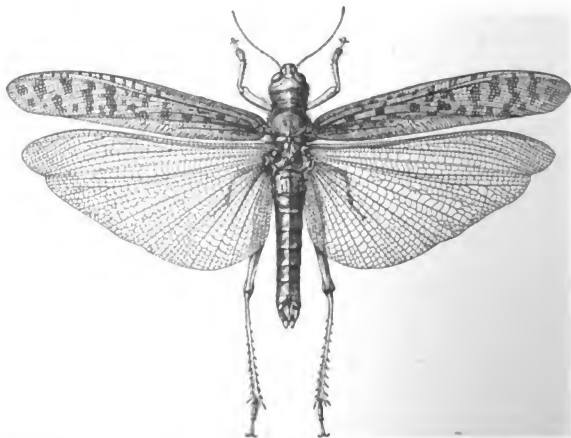


Fig. 35.—A common migratory Locust (*Schistocerca gregaria* = *Acridium peregrinum*). Three-fourths (linear) of the natural size.

138. An African Locust, *Cyrtacanthacris lineata*, as an example of an Orthopterous Insect.

BUGS, CICADAS AND APHIDS (HEMIPTERA OR RHYNCHOTA).

In Hemipterous Insects both pairs of wings are usually developed. In one division (Heteroptera) the front wings are firmer and darker than the hind wings, but this is not the case in the Homoptera (*e.g.*, Cicadas and Lantern-flies). In many cases the hind wing is secured to the front wing in such a manner that the two wings of the same side move as one structure. In Water-Bugs there is a single hook near the back of the front wing which fits into an upwardly directed flange on the front edge of the hind wing. In Cicadas and Lantern-flies the hind margin of the front wing is turned down for a part of its length, and hooks over an upturned portion of the front margin of the hind wing. See slides B and C shown under the microscope.

139-141. A Trinidad Water-Bug, *Belostoma grandis*; a Bornean Cicada, *Pomponia imperatoria*; and a Lantern-fly, *Fulgora candelaria*; as examples of Hemipterous Insects.

142. Diagram of a section taken through the wings of a Cicada or a Lantern-fly showing the mode of interlocking. See fig. 36.



Fig. 36.—Diagram of a section taken through the wings of a Cicada, or a Lantern-fly, showing the mode of interlocking.

FOLDING OF THE WINGS OF INSECTS.

The specimens that follow illustrate the mode of disposal of the wings of Insects on their coming to rest. The term "folding" is in this connection commonly used in two different senses, (*a*) the disposition of the wings with regard to the body, and (*b*) the bending or doubling up of the individual wings. Thus it is customary to speak of the wings being folded up vertically over the back in Butterflies and Dragon-flies, and folded like a gable-roof over the abdomen in Moths and Ant-lions. Here there is no

wrinkling or doubling up of the individual wings such as occurs in the hind wings of Earwigs and Beetles.

LEPIDOPTERA.

Most Butterflies (143) on coming to rest set the wings straight up over the body, the upper surfaces of the front wings being almost in contact. Most Moths (144) in a state of rest dispose their wings backward over the abdomen, the front wings covering the hind wings, and presenting the form of a gable-roof. Some Moths, however, such as most of the Geometer-Moths (145), rest with the wings widely spread, almost as in flight. Some of the Plume-Moths (146) fold up the two wings of the same side in a line at right angles to the body, so that the wings and the body present more or less the appearance of the letter T; but the Many-plume Moth (*Orneodes*) settles with wings expanded, presenting the characteristic appearance which has earned for it the name of Fan-Moth. Other Moths, such as the Lappet-Moths, Poplar Hawk-Moth (147), Lime Hawk-Moth, etc., rest with the wings spread sideways, the front wings sloping backward over the hind wings.

143. A Butterfly (Camberwell Beauty, *Vanessa antiopa*) in the attitudes of flight and rest. In a state of rest the wings are set vertically above the body.

144. A Moth (Indian Death's-head Moth, *Acherontia atropos styx*) in the attitudes of flight and rest. In a state of rest the wings slope backwards over the abdomen, the front wings covering the hind wings and presenting the form of a gable-roof.

145. Small Dusky Wave-Moth, *Acidalia virgularia*, one of the Geometer-Moths, in a state of rest—an example of a Moth which rests with the wings widely spread, almost as in flight.

146. A Plume-Moth, *Pterophorus monodactylus*, in the attitudes of flight and rest. The two wings of the same side close up in a line at right angles to the body, the wings and the body thus presenting the appearance of the letter T.

147. Poplar Hawk-Moth, *Smerinthus populi*. In a state of rest the hind wings remain as much outspread as in flight; the front wings slope backward over them.

NEUROPTERA.

In Neuropterous Insects the two pairs of wings may in a state of rest be held vertically over the back, as in Dragon-flies (148), or may fold over the abdomen in the form of a gable-roof, as in Ant-lions (149), or over the abdomen horizontally, as in the Perlidae (150), only one of the front wings being then visible. The individual wings usually remain flat, but in the Perlidae the hinder portions of the second wings become plicate.

148. A Dragon-fly, *Pantala flavescens*, in the attitudes of flight and rest.

149. An Ant-lion, *Palpares speciosus*, in the attitudes of flight and rest.

150. A Perlid, *Perla* sp., in the attitudes of flight and rest.

HYMENOPTERA.

In the Wasps (true Wasps, Diploptera or Vespidae, e.g. Hornet, 152) the wings are sloped straight backward when the insect comes

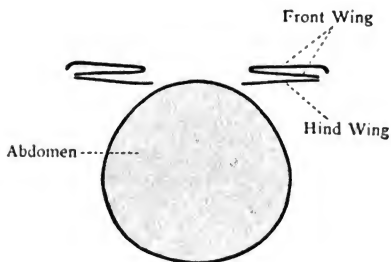


Fig. 37.—Section across the abdominal region of a Hornet (*Vespa crabro*), showing the shape of a Z presented by the cut edges of the doubled front wing and the hind wing underneath it.

to rest, and the front wings undergo a longitudinal folding in such a manner that each appears V-shaped in cross section. The hind half of the front wing folds under the front half, and so there is no necessity for the unhooking* of the fore and hind wings of the same side. In all other Hymenoptera—Sand-Wasps, Bees

* The mode of hooking of the hind wing upon the fore wing in Hymenoptera is illustrated by slide A shown under the microscope.

(e.g. 151), Saw-flies, etc.—excepting of course the wingless forms, the wings remain flat when in a state of rest.

151. Humble-Bee or Bumble-Bee, *Bombus terrestris*, in the attitudes of flight and rest.

152. Hornet, *Vespa crabro*, in the attitudes of flight and rest.

153. Diagram of a section across the abdominal region of a Hornet, *Vespa crabro*, showing the shape of a Z presented by the cut edges of the doubled front wing and the hind wing underneath it (see fig. 37).

ORTHOPTERA.

In most Orthoptera the front wings are stiff and are known as tegmina. Like the elytra of Beetles, they close over the hind wings and protect them when the insect is at rest. The hind wings in Locusts (155, fig. 35) and Grasshoppers are large, and fold up in a fan-like manner beneath the tegmina. In the Fan-wing (156, fig. 38) the resemblance to a fan is even greater than in the Locusts; the front edge of the wing is stiff, and the tegmina are short and narrow. In the Cockroach (154) it is only the hinder part of the wing which folds up in a fan-like manner.

154–156. A Cockroach, *Periplaneta americana*, a Locust, *Orthacanthacris aegyptia*, and a Fan-wing, *Rhipipteryx limbata*, showing the differing degrees to which the hind wings are capable of folding up in a fan-like manner.

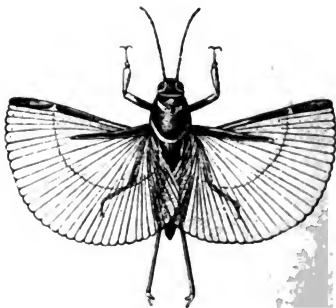


Fig. 38.—Fan-wing (*Rhipipteryx limbata*). ($\times 3$). The hind wings are large, and fold in a fan-like manner (see 156).

157. Earwig (*Forficula auricularia*, fig. 39). The first pair of wings, or tegmina, are stiff and are not used for flight; they serve to protect the second pair or wings proper when these are not in use. The mode of folding up of the wings is highly complicated, and is here explained by the paper models A-F, enlarged seventeen times linear. The drawing A shows the shape of the wing (right wing, seen from above), the arrangement of the veins of the wing (in black), and the lines of folding (in red). The black and red lines are not repeated in the models B-F. When the wing of the Earwig folds up on the insect coming to rest after flight, the whole of it except the basal part folds after the manner of a fan (B). When the fan is nearly closed, it bends sharply in

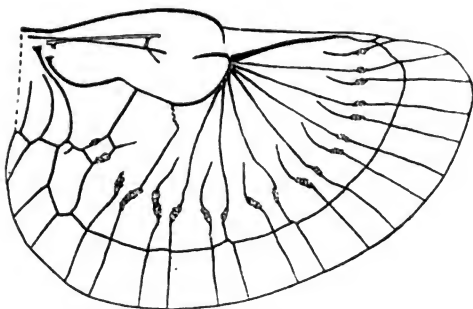


Fig. 39.—Wing of an Earwig (*Forficula auricularia*). ($\times 8$).
(See 157.)

the middle of its length (C and D) and comes to lie compactly under one half of the basal part of the wing (E). This half of the base of the wing then folds under the other half (F), and the process is complete.

On the card at the right lower corner of the series are shown four actual specimens of right wings in phases of unfolding.

DIPTERA.

In Dipterous Insects or Flies the wings remain flat in a state of rest. They are sloped somewhat backward, as in Blow-Flies (158) and House-Flies, or may be so much directed backward that the one wing completely covers the other, as in Tsetse-Flies (159).

158-159. A Blow-Fly, *Calliphora erythrocephala*, and a Tsetse-Fly, *Glossina palpalis*, in the attitudes of flight and rest.

COLEOPTERA.

In Coleopterous Insects or Beetles the front wings are modified into hard, shell-like elytra, which do not beat the air during flight, but which serve to protect the hind wings, or wings proper, when the insect is at rest. The wings are much larger than the elytra, and in order that they may be stowed away beneath the wing-covers they are provided with special means of folding up.

160. Goliath-Beetle, *Goliathus giganteus*, dissected to show the mode of folding of the wings when at rest. The elytra have been removed so as to expose the wings; the right wing is shown fully folded, the left wing partially folded. Below the Beetle is the left wing, fully extended, from another specimen (see fig. 40).

In the three wings shown, *a* marks the part which is hinged upon the body; *b* is the folding joint, the place where the outer half of the wing folds upon the basal half, somewhat after the manner of the blade of a pocket-knife; *c* is the tip of the wing, which when the insect is at rest is set close to the basal part of the wing of the opposite side.

161. Goliath-Beetle, *Goliathus giganteus*, in the attitude of rest. The wings are completely concealed beneath the elytra.

162. A curious Carabid Beetle, *Mormolyce phyllodes*, from the Malay Peninsula, in the attitudes of flight and rest. The edges of the elytra are produced into flat leaf-like expansions, so that the elytra as a whole are larger than the wings. The wings fold up beneath the middle part of the elytra, not under the lateral plates. Very possibly these plates act as "planes," serving to maintain the weight of the body in the air, while the wings supply the motive power to drive the body forward through the air.

163. *Ctenoscelis acanthopus*, a Longicorn Beetle of the sub-family Prioninae. Whereas in the Goliath-Beetle (160, fig. 40) the joint in the wing (*b*) occurs about half-way between the hinge (*a*) and the tip (*c*), in this and most Longicorn Beetles the joint occurs much nearer to the tip than to the hinge. In the specimen shown the elytra are removed, and the left wing is expanded as in flight, while the right wing is folded.

In certain genera of the family Cerambycidae, the joint in the wing is rather near the tip, and the elytra being relatively small,

the wings are freely visible when the insect is at rest. In the genera *Necydalis* and *Clytarlus* the position of the joint near the

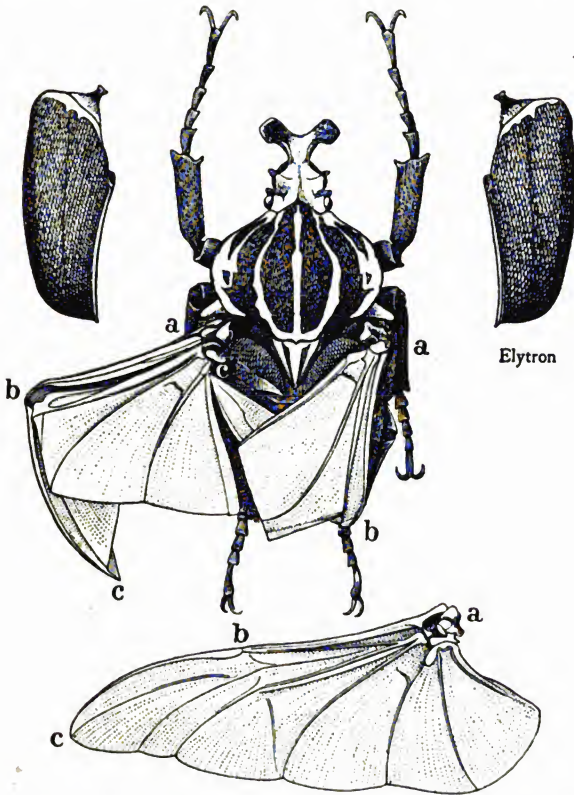


Fig. 40.—Goliath-Beetle (*Goliathus giganteus*), dissected to show the mode of folding of the wings when at rest. (For explanation see 160.)

end of the wing is recognisable, but the joint is functionless, and the wings remain flat when not in use—such insects do not look like Beetles, and are mostly mimetic forms.

164. Cock-tail or Devil's Coach-horse Beetle, *Ocypus olens*, with the right elytron removed to show the much folded wing. On the card are mounted the wings of three other specimens, together with the pair of elytra of one of them. The upper pair of wings are fully expanded; *a* marks the base or hinge, *b* the principal joint, situated nearer the base than in the Goliath-Beetle (160), and *c* the tip of the wing. The pair of wings mounted below these show the first stage in the process of folding, the part *b c* becoming bent at right angles to the part *a b*. The next pair exhibit a folding of the part *b c* along the lines indicated by the vertical pencil marks, dividing the right wing into three parts and the left wing into two. The tips of both wings thus come to point to the left. The two wings when fully closed are completely concealed beneath the two elytra. In some individuals it is in the left wing that the part *b c* folds into three, and in the right wing into two.

HEMIPTERA OR RHYNCHOTA.

In the Homopterous division of the Hemiptera (*e.g.* Cicadas, 165) the four wings usually fold over the abdomen at an angle, presenting the form of a gable-roof, when the insect comes to rest; in the Heteropterous division the wings usually fold flat upon the abdomen (*e.g.* Water-Bugs, 166).

165-166. An Australian Cicada, *Henicopsaltria eydouxii*, and an Indian Water-Bug, *Belostoma indica*, in the attitudes of flight and rest.

CASE 4.

MICROSCOPE SLIDES ILLUSTRATING CERTAIN FEATURES OF THE WINGS OF INSECTS AND FEATHERS OF BIRDS.

Slide A—Middle part of the left fore and hind wings of a Humble-Bee, *Bombus lucorum*; under surface. The two wings are separated, but in the living insect the hooks seen along the edge of the hind wing hook upon the scroll-like edge of the front

wing, so that during flight the two wings move as one structure (see fig. 41).

Slide B—Middle part of the right front wing of an Arabian Water-Bug, *Laccotrephes fabricii*; under surface. The short,

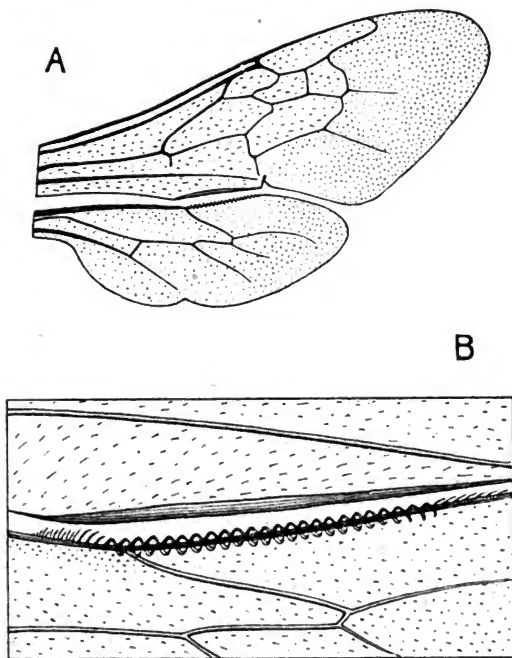


Fig. 41.—Wings of a Humble-Bee (*Bombus lucorum*). A, front and hind wings of the left side seen from below. The hind wing is in the living animal securely fastened by the row of hooks along the middle part of its front edge to the curved scroll that occurs in the middle part of the hind edge of the front wing, but in this figure the wings are drawn separated, so as to show more distinctly the hooks of the scroll. B, the middle part of figure A further enlarged, showing the row of hooks along the front edge of the hind wing and the scroll along the hind edge of the front wing (see microscope slide A).

broad hook, brown in colour, which is seen standing out towards the observer, fastens over a scroll-like front margin of the

hind wing, so that during flight the two wings move as one structure.

Slide C—Middle part of the left hind wing of a South European Cicada, *Tettigia orni*; upper surface. The upturned scroll of the front edge of the hind wing hooks beneath the scroll-like hind edge of the front wing, so that during flight the two wings move as one structure (see fig 36).

Slide D—Basal portions of the left front and hind wings of the male of a small species of Hawk-Moth, *Macroglossa trochiloides*; under surface. The scales have been removed. A long, curved, tapering bristle, the frenulum, projects from the front edge of the base of the hind wing, and fits into a kind of recurved strap or hook, the retinaculum, on the under side of the front wing (see fig. 31). This mode of ensuring a co-ordinated action of the two wings of the same side of the body is common among Moths, but does not occur in Butterflies (see 122).

Slide E—Isolated frenula of the female and male of a Tineid Moth, *Cryptophaga epadelpha*. In this, as in most Moths, the frenulum of the female consists of a few (usually three) bristles, and that of the male of a single structure, longer and thicker than the bristles of the female.

Slide F—A piece of the front wing of a Death's-head Hawk-Moth, *Acherontia atropos*; upper surface. The scales are ordinary scales such as are characteristic of Moths and Butterflies, which insects are denoted Lepidoptera because of their scaly investment (Greek; *lepis* (*lepid*-), a scale; and *pterón*, a wing).

Slide G—A piece of the front wing of a South African Emperor-Moth, *Gynanisa maia*; under surface. The region selected shows a transition from ordinary scales such as are seen in slide F to very long scales (see fig. 42, A, D, E). The elongation is shared by the teeth of the scales as well as the bodies of the scales. The parts of wings bearing such scales have the appearance of a soft fur.

Slide H—A piece of the front wing of a Convolvulus Hawk-Moth, *Protoparce convolvuli*, taken from near the hind edge; upper surface. The region selected shows a transition from ordinary scales to very long scales in which the teeth are not longer than in ordinary scales (see fig. 42, A, B, C). The parts

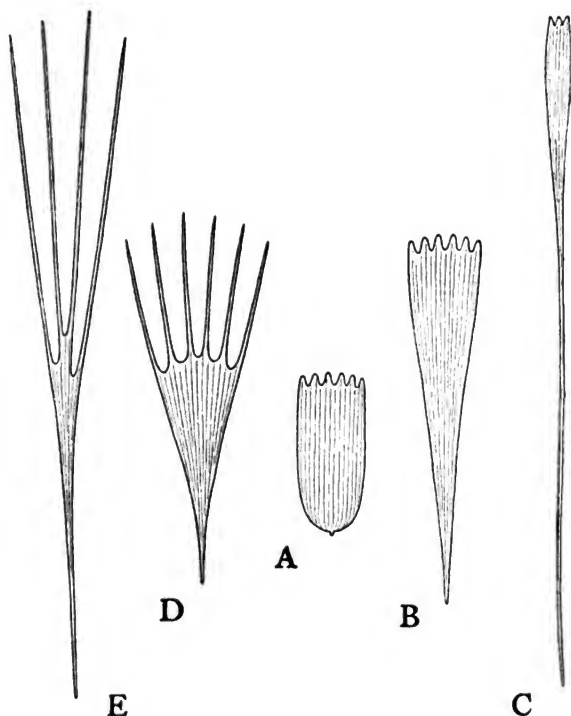


Fig. 42.—Diagrams of Scales of Moths, greatly enlarged. A, a typical scale such as is found on the wings of most Lepidoptera. The scale is attached by a short narrow stalk, and the free edge is provided with a number of projections or teeth. B, a long narrow scale, and C, a very long scale, almost like a bristle, with a small flattened part near the free end, and with a few teeth only. D, a scale with elongated teeth, and E, a long scale with very long teeth, fewer in number than those of scales such as A and D. The hairy or furry patches on the wings of Butterflies and Moths owe their peculiar appearance to scales such as those of type C or those of type E. Both kinds of elongated scales (C and E) may occur together. Figures A, B and C are drawn from scales of the wing of the Light Crimson Underwing Moth (*Catocala promissa*), and figures D and E from those of a South African Emperor-Moth (*Gynanisa maia*) (see microscope slides F, G, and H).

of wings bearing such scales have the appearance of a coarse or bristly fur.

Slide J—Left wing of a House-Fly, *Musca domestica*; upper surface. In Flies (Diptera) only the first pair of wings are developed as organs of flight, the second pair being modified into small stalked balancers or "halteres." In slide J the halter is seen through the hood-like extension of the base of the wing.

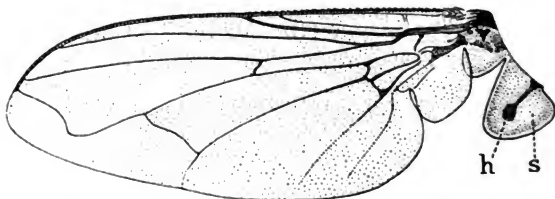


Fig. 43.—Left wing of a House-Fly (*Musca domestica*), with the halter (*h*) showing through the transparent squama (*s*) (see microscope slide J).

known as the "squama" (see fig. 43). The halter is, so far as can be judged, a sense organ enabling the animal to maintain the equilibrium of the body.

Slide K—*Caraphractus cinctus*, a minute Hymenopterous insect of the family Mymaridae (see fig. 44). The special interest attaching to this insect is that it flies under water, or swims by means of its wings (compare the Penguins among Birds). The Mymaridae are commonly known as Fairy-flies, and include some of the smallest winged insects known. *Caraphractus cinctus* is aquatic in habit, and lays its eggs in the eggs of Dragon-flies.

Slide L—Portion of a wing-feather of the Bearded Vulture, *Gypaetus barbatus*, upper surface, showing the manner in which the barbules of the one side of each barb fasten by means of their hooklets upon the scroll-like edges of the barbules of the other side of the next barb, across which they lie obliquely (see fig. 20, B and C). In the slide two of the barbs have been partly separated from the rest so as to show more distinctly the form of the barbules. For further details of the structure of a feather see the enlarged model 63 B.

Slide M—Portion of a feather of the American Ostrich, *Rhea americana*. The barbules on the two sides of each barb are alike; they have neither scroll-like edges nor hooks such as are seen in

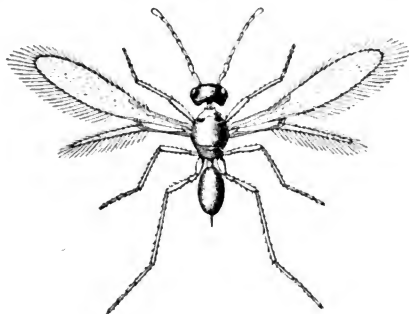


Fig. 44.—*Caraphractus cinctus*, a minute aquatic Hymenopterous insect which flies under water, or swims by means of its wings. The hind wings are reduced in width, and both front and hind wings are fringed with hairs (see slide K).

the feather of the Vulture (slide L). Feathers of this type are more fluffy than those in which the barbules are hooked together. Compare fig. 20, A, with fig. 20, B and C.

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BRITISH MUSEUM (NATURAL HISTORY)

SPECIAL GUIDE No. 7

GUIDE TO THE SPECIMENS
AND ENLARGED MODELS OF

INSECTS

AND TICKS EXHIBITED IN THE

CENTRAL HALL

ILLUSTRATING THEIR IMPORTANCE
IN THE SPREAD OF

DISEASE



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PREFACE.

THE method of explaining to visitors the general appearance and the details of the external features of insects by means of models on a large scale, rather than by the more customary drawings, was first adopted by Sir E. Ray Lankester, Director of the Museum, in the year 1900. The earliest models were those of two mosquitoes and a tsetse-fly. After Sir Ray Lankester's retirement in December 1907, the method was followed up by the preparation of a model of a flea (presented by the Entomological Research Committee); more recently, models of a house-fly and a tick have been added. During the present year the series of disease-spreading insects and ticks has been further increased by placing on view a collection of specimens and models of tsetse-flies, tabanid flies, mosquitoes and ticks; this collection was prepared, on behalf of the Exhibitions Branch of the Board of Trade, in 1913, under the direction of Mr. E. E. Austen, Assistant in the Department of Entomology, and was shown in the "Tropical Diseases" Section of the International Exhibition at Ghent in the summer of that year. The models have been kindly lent to the Museum by the Board.

Only those insects and ticks that are of importance in the spread of disease have been selected for exhibition in the middle of the Central Hall; the general series of insects and ticks is to be found in the Arthropod Gallery, in the West Wing of the Museum; the collection of insects injurious to crops is exhibited in the North Hall.

The large models shown in the Hall were constructed under the supervision of expert entomologists by Mrs. E. D. Blackman and Miss Grace Edwards, and so far as is possible they are correct in the smallest details.

The present guide-book is to a large extent a compilation, made by Dr. W. G. Ridewood, of the exhibited labels that accompany the insects and the models.

The acknowledgments of the Trustees are due to Drs. Castellani and Chalmers for permission to use the figures of the house-fly, bed-bug and tick given in their *Manual of Tropical Medicine*.

L. FLETCHER,

Director.

BRITISH MUSEUM (NATURAL HISTORY),
December, 1915.

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INSECTS AND TICKS AND THEIR IMPORTANCE IN THE SPREAD OF DISEASE.

INTRODUCTION.

THE entrance to the museum is at the South end of the Central Hall, and the main staircase at the North end; the side of the Hall to the right of the visitor as he enters is the East. The Bays or Recesses around the Hall are designated by numerals, painted below the end windows. On the East side the most southern bay, that near the statue of Prof. Huxley, is No. X; on the West side the southern bay, with the bust of Sir William Flower against the arch, is No. I.

The grouping of the objects in the following pages is one based upon the systematic position of the insects themselves, and not according to the sequence of the show-cases in which they are exhibited. This arrangement has the effect of causing a visitor who reads the pages consecutively to walk away from a case before exhausting it, and to return to the case later in order to see other insects contained in it; but the method has the advantage of preventing any mental confusion that might possibly arise from a study of both mosquitoes and tsetse-flies in one show-case, followed by an examination of mosquitoes and tsetse-flies in other cases. It is preferable to complete the examination of all the mosquitoes exhibited, and then to commence the study of the tsetse-flies, and to pass on subsequently to other groups of insects in their turn.

While most of the specimens are displayed in ordinary museum show-cases, a few, mainly fleas, are shown under two microscopes of special construction which permits of the examination of several specimens in succession. The slides are

attached to a drum, which rotates upon its axis by means of a milled wheel operated by the visitor. Another milled wheel at the side of the instrument enables the visitor to adjust the focus to suit his own eyesight. The microscope on the West side of the Hall carries twelve slides, that on the East five slides.

MOSQUITOES AND MALARIA.

MALARIA is a disease of man caused by minute parasites that invade the red corpuscles of the blood. The parasites belong to a very low grade of animals, and are included in the division of the Protozoa known as *Hæmosporidia*.

Formerly malaria, commonly known in this country as ague, was thought to be contracted by breathing the air of marshy districts, but it is now proved that it is due to these parasites, transmitted from man to man by the bite of certain kinds of mosquitoes or gnats. Although there are many hundreds of species of mosquitoes, it is only those belonging to the genus *Anopheles*, and only certain species of that genus, that are capable of conveying malarial parasites to man. The parasite multiplies not only in the human blood, but also in the walls of the stomach of the mosquito.

Various forms of malaria are distinguished by medical men according to the frequency of the recurrence of fever and other symptoms, as tertian, quartan, etc. Each is due to a distinct species of parasite, though the visible differences between the species are very slight. The parasite of pernicious or aestivo-autumnal fever is known under the name of *Plasmodium falciparum* Welch (= *Laverania malariae* Grassi and Feletti); that of tertian fever is *Plasmodium vivax* Grassi and Feletti, and that of quartan fever, *Plasmodium malariae* Laveran. Parasites similar to these frequently occur in the blood of other mammals, more especially in that of apes and monkeys, and also in the blood of birds of many species.

Malaria is now almost extinct in Northern Europe, but in many parts of the tropics it is still one of the commonest of diseases. At the beginning of the present century, however, practical measures for the extermination of mosquitoes were introduced in many parts of the tropics, and the rigid enforcement

of these precautions has frequently been followed by marked diminution in the prevalence of malaria, or even its total or almost complete disappearance.

In a table-case that stands at the entrance to Bay X, near the statue of Prof. Huxley, are shown two greatly enlarged models ($\times 28$) of one of the malaria-carrying species of mosquito, *Anopheles maculipennis* Mg., together with an actual specimen, for the purpose of giving a correct impression of the real size of the insect. The model on the left hand panel shows the attitude of the mosquito when flying (fig. 3, p. 15); that on the right hand panel shows its attitude when at rest (fig. 2, A). Both of the models represent the female insect, for in the species of mosquito that suck blood the blood-sucking habit is confined to the female. In the case of an infected mosquito capable of communicating the disease, the young forms of the malarial parasite escape into the blood with the secretion of the salivary glands, which is introduced into the wound at the time of the bite.

In the middle part of this case is shown a series of greatly enlarged models ($\times 6,000$) illustrating the complete life-cycle of the parasite of pernicious or aestivo-autumnal malarial fever, *Plasmodium falciparum*, some stages of which are passed through in the blood of man, others in the body of the mosquito. The models are numbered consecutively, and are explained in the following terms:—

1.—A malarial germ or sporozoite (fig. 1, *a*), as introduced into the blood of man by the proboscis of a female anopheline mosquito.

2.—The sporozoite penetrates into a red blood-corpuscle, and becomes rounded off into a compact mass (fig. 1, *b*).

3.—The parasite enlarges and a vacuole appears within it. Signet ring stage.

4.—The vacuole disappears, and the parasite enlarges and emits blunt processes. Amoebula stage.

5.—The nucleus multiplies, and the pigment granules increase in number (fig. 1, *c*).

6.—The nuclei arrange themselves at the periphery. Rosetto stage.

7.—The daughter-individuals (merozoites) separate from the central non-nucleate protoplasm (fig. 1, *d*).

8.—The merozoites become free in the blood-plasma by the disintegration of the red corpuscle (fig. 1, *e*). Each merozoite invades a red blood-corpuscle, and develops into amoebula, rosette, and further merozoites, as explained in the preceding models.

9, 10.—After several cycles of amoebula, rosette, and merozoites, a merozoite on entering a red corpuscle grows into a sexual form which may be crescentic (fig. 1, *f*).

11.—The crescent increases at the expense of the corpuscle, and male crescents become distinguishable from female crescents, as explained in models 12 and 15. The crescents undergo no further change in human blood, but when blood containing crescents is sucked by a female anopheline mosquito, the crescents undergo development.

12.—The male crescent (fig. 1, *g*) is shorter and more rounded than the female crescent. It has clearer protoplasm and a larger nucleus, and the pigment granules are more scattered.

13, 14.—The male crescent becomes spherical and the nucleus multiplies.

15.—The female crescent (fig. 1, *h*) has denser protoplasm and a smaller nucleus than the male, and the pigment granules are in the middle part of the crescent.

16, 17, 18.—The female crescent becomes spherical, and, after extruding two small cells (? polar bodies) in succession, becomes the macrogamete or ovum, and is ready for fertilisation.

19.—The male sphere shoots out four, five or six slender processes (microgametes or sperms) consisting mainly of nuclear material (fig. 1, *i*). The remainder of the sphere plays no further part in the life-history.

20. A microgamete is attracted by, and enters into an ovum (fig. 1, *j*).

FIG. 1.—LIFE HISTORY OF THE ORGANISM OF PERNICIOUS MALARIA.

a, malarial germ or sporozoite, as introduced into the blood of man by a female anopheline mosquito at the time when it is sucking blood; *b*, sporozoite after entry into a blood-corpuscle of man; *c*, growth of the sporozoite into an amoebula; *d*, division of the amoebula to form merozoites; *e*, liberated merozoites; *f*, growth of a merozoite into a crescent; *g*, free male crescent; *h*, free female crescent; *i*, male cell with projections, which lengthen and are set free as sperms; *j*, fertilisation of an ovum by a sperm; *k*, fertilised egg as an active motile vermicle; *l*, sphere formed from the enlarged vermicle, after this has bored through the stomach-wall of the mosquito; *m*, portion of the sphere or cyst at a late stage of development, containing countless needle-shaped spores, which, when the cyst bursts, escape as sporozoites into the organs of the mosquito's body, and pass through the salivary glands into the proboscis, and so infect a man bitten (i.e. pricked) by the mosquito. *a-l* are enlarged 3,500 diameters; *m* is drawn to a smaller scale of magnification.

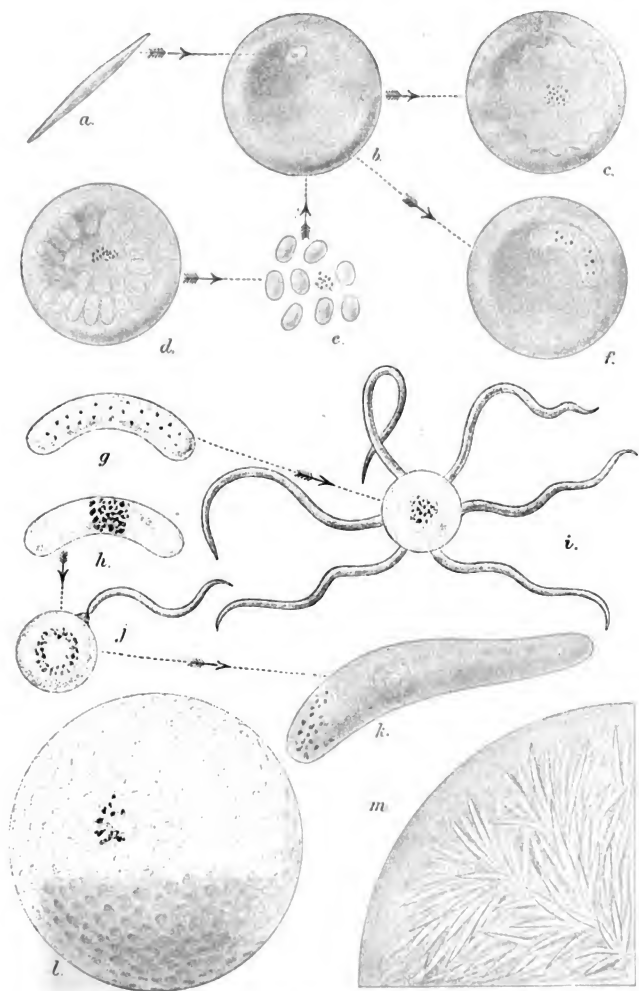


FIG. 1.

21.—On entry into the ovum the microgamete becomes a nucleus. The two nuclei unite, and the fertilised ovum or zygote becomes motile.

22.—The zygote elongates and bores its way through the wall of the stomach of the mosquito. Oökinete or vermicule stage (fig. 1, *k*).

23.—On the outer surface of the stomach of the mosquito the oökinete becomes spherical, and increases greatly in size, the nucleus multiplying at a rapid rate. A protective covering or cyst forms around the sphere. (Only one half of the sphere is shown.)

24.—The sphere divides up into sporoblasts, each being a small cell with a single nucleus (fig. 1, *l*). (Only one half of the sphere is shown.)

25.—In each sporoblast the nucleus divides into a great number of small nuclei, and the surface of the sporoblast grows out into a great number of pointed processes, into each of which a nucleus enters. These nucleated processes elongate further, and separate from the central part of the sporoblast, and become motile spores or sporozoites (fig. 1, *m*). (The model shows only one half of the cyst.) On the bursting of the cyst the sporozoites escape into the various organs of the body of the mosquito.

26.—Free motile sporozoites. Such of these as reach the salivary glands pass through the ducts of the glands into the proboscis, and when next the mosquito pricks the skin of a man for the purpose of sucking blood, some of them are left in his body, and develop in the red corpuscles in the manner explained by the models in the upper part of the series.

In the large table-case that stands in Bay VI, on the East side of the main staircase, are shown models of the malarial parasite somewhat similar to those just referred to, but of earlier construction. They illustrate the phases in the life-history of the organism so far as they were known at the time when the models were made (1901); the more recent series, in the case near Bay X, embodies the results of investigations up to May 1913.

On the sloping panels in this table-case in Bay VI are mounted enlarged models ($\times 28$) of one of the malaria-carrying mosquitoes, *Anopheles maculipennis* Mg., similar to the two models already seen in the other case (Bay X). Side by side with these are shown, for purposes of comparison, enlarged models of another

gnat or mosquito, *Culex pipiens* Linn., an insect which, although it can make itself unpleasant, does not transmit malaria.

The models on the South side of the case represent the insects in the resting attitude, and illustrate a characteristic difference between anopheline and culicine mosquitoes. The former have the proboscis, thorax and abdomen set in a straight line, whereas culicine mosquitoes, when viewed from the side, have a hump-backed appearance, owing to an arching of the thorax, so that the line of the proboscis is set at an angle to the axis of the hinder part of the body. When resting on a wall or other flat surface, a

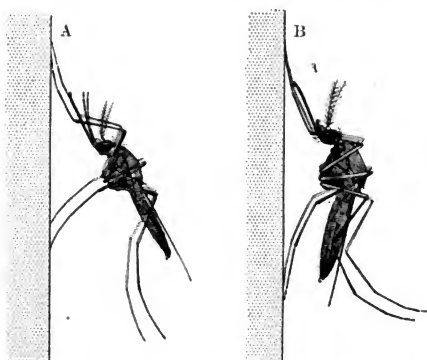


FIG. 2.—ANOPHELINE AND CULICINE MOSQUITOES IN RESTING ATTITUDE.

- A. *Anopheles maculipennis*, female, $\times 4$.
 B. *Culex pipiens*, female, $\times 4$.

culicine keeps the abdomen more or less parallel to the surface, whereas an anopheline slopes the abdomen away (fig. 2). Anophelines nearly always have spots on the wing. In both sexes of anopheline mosquitoes the maxillary palps are as long as the proboscis, and those of the male are clubbed at the tip. In culicines the palps of the female are much shorter than the proboscis, and those of the male are a little longer than the proboscis, and usually not clubbed at the tip—in mosquitoes the male can be readily distinguished from the female by the more plumose or fluffy antennae. In culicines the abdomen is completely clothed with scales like those on a moth's wing, some of the scales forming

in many species conspicuous white transverse bands at the base of each segment; in anophelines the abdomen is without distinct scales, and hence without well-defined markings.

In the lower part of the South side of the case are displayed a series of models, enlarged 28 diameters, like those of the adult insects, showing the appearance of the eggs, the larvae and the pupae of *Culex* and *Anopheles*. The black threads stretched horizontally represent the surface of the water. The eggs of mosquitoes float upon the surface, and the larvae and pupae move about in the water, breathing by means of their air-tubes, which now and again are caused to project very slightly above the surface. The eggs of *Culex* are massed into a raft composed of two or three hundred eggs with their more pointed ends directed upwards. The eggs of *Anopheles* float singly or in small groups easily scattered by the wind, and are disposed on their sides instead of standing erect upon the water. Each egg has a pair of small air spaces, as shown in the upper model ($\times 65$) at the right hand end of the series, above the group of eggs ($\times 28$).

The characteristic attitude of the larva of the culicine mosquito is one in which the head is downmost, the body slightly inclined to the vertical, and the extremity of the air tube at the hind end of the body just touching the surface of the water. The larva of the anopheline mosquito rests horizontally just below the surface of the water; the air-tube at the hind end of the body is very short, and just level with the surface. When feeding, the larva twists its head half-way round, and laps the surface of the water for minute vegetable organisms. Both culicine and anopheline larvae when alarmed strike down into the water with a rapid jerking movement.

The pupae of the culicine and anopheline mosquitoes do not differ greatly. In each case the pupa rests with the two horn-like air-tubes on the thorax at the surface of the water, but it can swim rapidly by a jerking movement of the abdomen, which is provided at its extremity with two transparent paddle-like organs.

In the lower part of the North side of the case are enlarged drawings of the mouth-parts of the two species of gnat or mosquito illustrated, the culicine, *Culex pipiens*, and the anopheline, *Anopheles maculipennis*. The proboscis of mosquitoes consists of a long, channelled labium and six piercing instruments contained

within it—a labrum, a hypopharynx, a pair of maxillae, and a pair of mandibles. The labrum of mosquitoes is generally long, slender, and pointed, and grooved beneath for the reception of the hypopharynx, which lies immediately below, and has its apex more or less wrapped round by the inflected margins of the labrum. The two maxillae are long, and each tapers gradually to the apex, which is provided with fine teeth. The two mandibles are of the same length as the maxillae, and their tips partially embrace the apices of the maxillae. All these

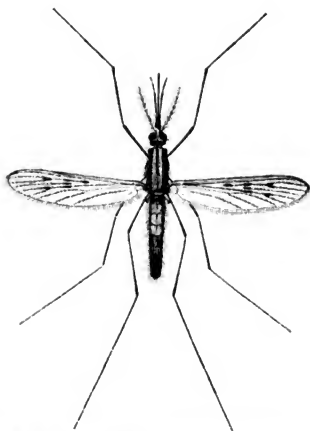


FIG. 3.—A MOSQUITO THAT SPREADS MALARIA,
Anopheles maculipennis, female, $\times 4$.

parts when at rest lie concealed in the labium, which is deeply channelled for their reception, and is furnished at its extremity with two fleshy lobes, the labella. The labium does not enter the skin of the animal attacked, but bends back beneath the body of the insect, the labella acting as guides to support the piercing organs.

In male gnats the mandibles are absent, and the maxillae are very short, and cannot be used as piercing instruments. The maxillary palps of the male *Culex* are as long as the proboscis,

and are somewhat brush-like, but in the female they are very short and simple.

In *Anopheles* the maxillary palps are long in both sexes. In the male the apical joint is thickened and hairy, and diverges from the proboscis, while in the female the palps are straight and lie close to the sides of the proboscis for their whole length.

The first three drawings exhibited show the head, as seen from above, of the female *Anopheles maculipennis*, and the female and male *Culex pipiens*. In order that the six piercing instruments may be clearly seen, they are represented as dislodged from the gutter-like labium, within which they are concealed in the living insect. The next two drawings show the forms of the extremities of the labrum, hypopharynx, maxillae and mandibles of female specimens of *Anopheles maculipennis* and *Culex pipiens*. The labrum is viewed from beneath, the other parts from above. The sixth drawing is that of a cross-section through the proboscis of a female *Culex pipiens*, showing the relative positions of the piercing organs when at rest; and the last is a diagram of the terminal portion of the labium of the same insect showing the form of the labella as viewed from above and from below.

On the sloping panel above the drawings are two diagrammatic models of the head of a female culicine mosquito or gnat, viewed from the side. The upper model shows the proboscis as it appears when beginning to pierce, the lower one shows the disposition of the parts when the lancets have penetrated a short distance into the skin. The labium does not enter the skin, but loops downward and backward beneath the body of the gnat, so that the six lancets are no longer enclosed in its gutter-like groove; the apposed labella continue to surround the lancets, and slide along them from point to base as the skin is penetrated.

For comparison with the culicine and anopheline mosquitoes there is shown, at the East end of the case, a model, enlarged 28 diameters like those of the mosquitoes, of a common midge, *Chironomus plumosus* Linn., a harmless insect, not to be mistaken for a mosquito or gnat. The model represents the female midge; the differences between the heads of the two sexes are illustrated in the two drawings above the model. An actual specimen of a male midge is also exhibited. *Chironomus plumosus* is one of the largest of the midges, and occurs in swarms in the air from April to August. The larger midges may be distinguished from

mosquitoes or gnats by the absence of the long proboscis, by the length of the front legs, and by their habit of resting with the front legs raised—in mosquitoes it is the hind legs that are raised when the insect is resting (see the models on the South side of the case).

In the lower part of this (East) end of the case is a model of the larva of *Chironomus plumosus*, a red, caterpillar-like, aquatic form sometimes termed a blood-worm. The larva lives in a tunnel which it makes at the bottom of some ditch, pool or rain-water butt. It breathes by means of four filaments, or blood-gills, at the hind end of the body, on the last segment but one, and four thicker processes on the last segment. Crawling movements are effected by a pair of foot-like organs beneath the head, and a pair at the hind end of the body. At night, and sometimes by day, the larva swims freely, jerking the body suddenly to the right and to the left in such a manner as to present the appearance of a figure of eight. When in its tunnel the larva imparts to its body an undulating movement, thus creating a flow of fresh water through the tunnel.

The series is completed by a model, enlarged 28 times linear like that of the larva and adult, of the pupa of the midge *Chironomus plumosus*. While still within its tunnel the larva turns into a pupa, and remains there, lying on its side and imparting an undulating movement to the body. The pupa breathes by means of a pair of tufted tracheal gills on the thorax. When approaching the stage of the imago or perfect insect, it leaves the tunnel and swims to the surface of the water; the skin splits along the back, and the winged midge emerges, and flies away almost immediately.

In the table-case that stands at the entrance to Bay I, near the bust of Sir William Flower, are shown dipterous insects of various kinds, tsetse-flies, tabanids and mosquitoes, selected because of their capacity for spreading diseases, and mounted together with examples of their near relatives, which, so far as our present knowledge goes, are harmless. Since almost all insects associated with maladies are of small size, the specimens are mounted close to the glass of the case, in order to enable visitors to see as much as possible of their general appearance and external characters. The mosquitoes of this series are on the West side of the case, away from the middle of the Hall. Examples are shown of both males and females, and the

geographical distribution of each of the species of which examples are shown is explained by means of a small map, with the regions in which the insect is found marked in red.

The following species of mosquitoes are exhibited, all known to convey the parasites of malaria from man to man, and thus to disseminate the disease:—*Anopheles maculipennis* Mg. (fig. 3, p. 15), *A. bifurcatus* Linn., Europe and North America—*A. (Myzomyia) listoni* Liston, *A. (M.) culicifacies* Giles, *A. (Myzorhynchus) barbirostris* v.d. Wulp, *A. (M.) sinensis* Wied., *A. Neocellia stephensi* Liston, *A. (N.) willmori* James, *A. (Nyssorhynchus) theobaldi* Giles, *A. (N.) fuliginosus* Giles, Asia—*A. (N.) maculipalpis* Giles, Asia and Africa—*A. (Myzomyia) funestus* Giles, *A. (Pyrethrophorus) costalis* Loew, *A. (Myzorhynchus) mauritianus* Grandpré, *A. (M.) paludis* Theob., *A. (Cellia) pharoensis* Theob., Africa—*A. (Nyssorhynchus) annulipes* Walker, Australia—*A. (Myzomyia) lutzi* Theob., *A. (Cellia) albianus* Wied., *A. (C.) argyrotarsis* Rob.-Desv., South America.

Disregarding for the present the mosquitoes that spread yellow fever and filariasis, these being dealt with in this guide-book under subsequent headings, the visitor arrives at a selection of "apparently harmless" mosquitoes—those which do not, or at all events are not known to, disseminate disease, namely:—*Anopheles (Christya) implexus* Theob., *Megarhinus separatus* Arrib., *Tororhynchites speciosus* Skuse, *Janthinosoma sayi* Dyar and Knab, *Stegomyia scutellaris* Walk., *S. apicoargentea* Theob., *Desvoidya obturbans* Walk., *Ochlerotatus cumminsi* Theob., *O. vittiger* Skuse, *Taeniorhynchus aurites* Theob., *Aedeomyia catacticta* Knab., *Theobaldia spathipalpis* Rond., *Culex concolor* Rob.-Desv., *C. annulirostris* Skuse, *C. tigripes* Grandpré, var. *fuscus* Theob., *Mimomyia plumosa* Theob., *Harpagomyia genurostris* Leic., *Eretmopodites chrysogaster* Graham, *Wycomyia communis* Leic., *Sabethes cyaneus* Fabr.

MOSQUITOES AND YELLOW FEVER.

So far as is at present known, yellow fever is disseminated solely by the mosquito *Stegomyia fasciata* Fabr., sometimes called the tiger-mosquito (fig. 4). As in all other mosquitoes that suck blood, the blood-sucking habit is confined to the female. The virus of the disease is introduced into the blood by the proboscis

of the infected insect at the time of the bite. Yellow fever is primarily a disease of the West Indies and the East Coast of Mexico, but it has been spread by shipping to many other parts of the world.

The causal agent of yellow fever is not known with certainty, although the disease has been attributed to an extremely minute protozoon found in the blood. That it is a living organism and not a chemical substance is evident from the fact that some time (about three days) elapses between the bite of the mosquito and the onset of the febrile symptoms, and a mosquito is not capable



FIG. 4.—A MOSQUITO THAT SPREADS YELLOW FEVER,
Stegomyia fasciata, female, $\times 4$.

of infecting until about twelve days after it has sucked the blood of a yellow-fever patient. These intervals of time are clearly periods during which an organism is undergoing some parts of its developmental process.

Specimens of *Stegomyia fasciata* Fabr. are shown in the series of mosquitoes on the West side of the table-case that stands at the entrance of Bay I. The species occurs in tropical and subtropical regions throughout the world, and is also found in Southern Europe and other countries bordering the Mediterranean Sea, and in the southern parts of the United States of America.

In a small case standing between the statue of Sir Richard Owen and the bust of Sir William Flower in Bay I is shown a model of the yellow-fever mosquito, *Stegomyia fasciata*, enlarged 28 diameters so as to be comparable with the enlarged models of *Culex pipiens* and *Anopheles maculipennis* shown elsewhere. On the back of the panel is a map showing the distribution of the species.

In general attitude a *Stegomyia* resembles a *Culex* rather than an *Anopheles* (fig. 2, p. 13); the thorax is arched, giving a hump-backed appearance to the body. The thorax of *Stegomyia fasciata* is black, with a conspicuous lyre-shaped white mark on the back; the tarsi are black, ringed with white at the base of each joint. In *Culex pipiens* the thorax is brown, without distinct markings, and the tarsi are black.

Essentially a domestic species, *Stegomyia fasciata* is always found in the vicinity of human habitations. Its wide distribution is believed to be largely due to the insect, in the egg, larval and adult stages, having been carried about the world in ships. It breeds not only in water-barrels and cisterns, wells, and the bilges of ships, but also frequently in puddles and pools of clean, foul, or brackish water, and even in a small quantity of rain-water standing in an old sardine-tin or broken bottle. The eggs are remarkably resistant, and are not necessarily rendered incapable of development if the water on which they are laid happens to dry up. In one instance some eggs of *Stegomyia* that had been kept in a dry state for six months gave rise to living larvae after being placed in water.

MOSQUITOES AND FILARIASIS.

Filariasis is a general term applied to diseases caused by thin thread-worms of the genus *Filaria*. Elephantiasis, one of these diseases, is due to *Filaria bancrofti* Cobbold, the embryos or larvae of which are carried from man to man by certain mosquitoes, particularly *Culex fatigans* Wied. Mosquitoes are also responsible for the spread of some other forms of filariasis, and it is interesting to note that some species of mosquito spread both malaria and filariasis.

In the table-case that stands at the entrance of Bay I are shown the following mosquitoes known to be instrumental in the spread of various forms of filariasis:—*Anopheles maculipennis* Mg. (fig. 3, p. 15), *A. (Myzorrhynchus) sinensis* Wied, var. *nigerrimus*

Giles, and var. *minutus* Theob., *A. (Myzomyia) rossi* Giles, *A. (M.) funestus* Giles, *A. (Pyrethrophorus) costalis* Loew, *A. (Cellia) argyrotarsis* Rob.-Desv., *Culex fatigans* Wied., *Stegomyia pseudoscutellaris* Theob., *Mansonioides uniformis* Theob., *Taenio-rhynchus titillans* Walk., *T. pseudotitillans* Theob.

FISHES THAT FEED UPON THE LARVAE OF MOSQUITOES.

By reducing the numbers of the larvae, and consequently the number of mosquitoes, certain fishes are beneficial in their effect, and lessen the chance of transmission to man of mosquito-borne diseases.

The five fishes exhibited in the glass vessel of alcohol are denoted by letters. A is the male, and B the female of a little fish known as "millions" (*Lebistes reticulatus* Peters). C is a female specimen of a "top-minnow" (*Gambusia affinis* Girard). D is a male, and E a female of *Haplochilus pumilus* Blgr., a fish without a popular name.

"Millions" (A and B) occur in fresh and brackish waters of Venezuela, Guiana, Trinidad, and the Windward Islands. The correct scientific name is *Lebistes reticulatus*, but the species has also been described as *Girardinus poeciloides* (from Barbados), as *Girardinus guppyi* (from Trinidad), and as *Poecilia reticulata* (from Venezuela). The females are viviparous; the males are smaller than the females, and have ornamental markings, whereas the females are plain in coloration. "Millions" are very prolific, producing a brood every few weeks. They have been exported into various tropical countries for the purpose of reducing the numbers of mosquitoes, but those recently introduced into Africa are said to have been devoured by the frogs.

"Top-minnows" (C) like "Millions," are viviparous, and belong to the Poeciliine group of the Cyprinodont fishes; they inhabit the Mississippi and fresh and brackish waters from Florida to Texas.

Haplochilus pumilus occurs in Lake Tanganyika and Lake Victoria in Central Africa; it is oviparous, and although it is known to devour mosquito-larvae but little has been recorded as to its natural history.

TSETSE-FLIES AND TRYPANOSOMIASIS.

Trypanosomiasis is a general term applied to diseases caused by species of Trypanosomes, small blood-parasites of an animal nature, belonging to the division of the Protozoa known as the Haemoflagellata.

Tsetse-flies are African, blood-sucking, dipterous insects, with peculiarly modified, piercing mouth-parts. The blood-sucking habit in tsetse-flies is common to both sexes, whereas in mosquitoes the females alone suck blood. The virus of the disease is introduced into the blood by the proboscis of the infected insect at the time of the bite.

In one of the cases in the middle part of the Hall, near the statue of Sir Richard Owen, is shown a large model ($\times 28$) of one of the tsetse-flies, *Glossina morsitans* Westw., which is mainly responsible for the spread of a deadly disease—nagana—among domesticated animals. In the blood of African animals, such as antelopes and buffaloes, there is frequently found a parasite, *Trypanosoma brucei* Plimmer and Bradford, which apparently causes little inconvenience to the host, but this, if transferred to a horse, ox or dog by the piercing proboscis of a tsetse-fly that has previously fed upon the blood of an infected antelope, gives rise to the nagana or tsetse-fly disease. The fatal disease of man known as sleeping sickness is spread by the tsetse-flies *Glossina palpalis* Rob.-Desv. (fig. 6, p. 25) and *G. morsitans* Westw. The organisms causing sleeping sickness are *Trypanosoma gambiense* Dutton (fig. 5) and *T. rhodesiense* Stephens and Fantham, in West and Central Africa and North-east Rhodesia respectively.

In the same case are shown actual specimens of the tsetse-flies *Glossina morsitans* and *G. palpalis*, and enlarged coloured drawings ($\times 2$) of the under and side views of a specimen of the former species, showing the collapsed and the gorged condition of the abdomen before and after a meal of blood. Another drawing, of the natural size, shows how the wings of a tsetse-fly overlap one another above the abdomen when the insect is at rest. In the glass vessel are four larvae at different stages of growth, and a pupa, of *Glossina palpalis*. The end of the pupa-case that bears the two projections is the hind end, as is explained in the enlarged drawing ($\times 12$) placed alongside.

Sketches are exhibited of a horse and a dog suffering from

nagana or tsetse-fly disease. In the horse the onset of an attack may be detected by the coat staring, and by a watery discharge from the eyes and nose. Shortly afterwards there appears a general swelling of the belly and hind extremities, which fluctuates from day to day. The animal hangs its head, and there is a general emaciation, sometimes accompanied by blindness. Death results from exhaustion; there are no symptoms of pain, and the appetite continues good till the last. In the dog the disease runs a rapid course, and is invariably fatal. The chief symptoms are extreme emaciation, swelling of the extremities, eruption over the body with the formation of blebs and pustules containing more or less purulent matter, and finally milky opacity of the cornea giving rise to blindness.

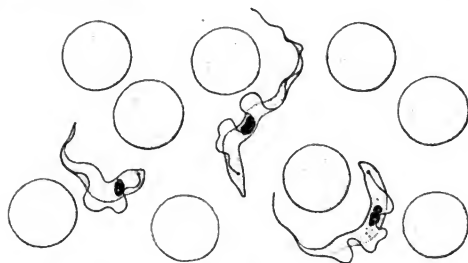


FIG. 5.—ORGANISMS OF SLEEPING SICKNESS,
Trypanosoma gambiense, and red blood-corpuscles; $\times 1,500$.

A map of Central and Southern Africa is exhibited, showing our knowledge of the distribution of the tsetse-flies (*Glossina*) in 1911, at the time of the issue of Mr. E. E. Austen's "Handbook of the Tsetse-Flies," published by the Trustees of the Museum.

Around the lower part of the case are shown enlarged coloured illustrations ($\times 6$) of the ten species of tsetse-flies that were known at the time of the publication of the book in 1911.

Displayed upon the glass shelf in the case are greatly enlarged transparent models ($\times 6,000$) of red blood-corpuscles and a form of trypanosome (*T. lewisi* Kent) found commonly in the blood of rats. Trypanosomes are small, elongated, parasitic animals occurring in the fluid part (plasma) of the blood; they have an undulating membrane or longitudinal fin which runs along the

body, and is continued forwards into a filament or flagellum. In an allied genus, *Trypanoplasma*, there is a flagellum at each end of the body.

Although many forms of trypanosomes are spread from one vertebrate host to another by tsetse-flies, some are spread by other blood-sucking invertebrates, such as gnats, fleas, leeches, etc.; the trypanosomes that are found in skates and similar fishes, for instance, are known to be conveyed by marine leeches. In the case is shown a specimen of an African fly, *Hippobosca rufipes* von Olfers, allied to the forest-fly of Britain, *Hippobosca equina* Linn. (see enlarged photograph ($\times 6$) below the glass plate), and responsible for the spread of the blood-parasite *Trypanosoma theileri* Bruce, causing gall-sickness among cattle in the Transvaal.

Other trypanosomes of interest in connection with disease are *T. equinum* Vosges, causing "mal de caderas" of horses in South America, *T. evansi* Steel, causing surra of horses and cattle in India, and *T. equiperdum* Doflein, causing dourine in horses in the countries around the Mediterranean Sea, and *T. cruzi* Chagas, the cause of the fatal disease barbeiro in man, particularly children, in South America, and conveyed by a hemipterous insect or bug, *Lamprophya megistus* Burmeister, more than an inch in length.

In the large case that stands at the entrance to Bay I, near the bust of Sir William Flower, is shown a selection of tsetse-flies, together with enlarged coloured drawings ($\times 6$), and maps showing the distribution of the several species. Tsetse-flies may be said to be African insects, although one species is met with in south-western Arabia, and in former times tsetse-flies existed in North America.

The first examples shown are those of *Glossina palpalis* Rob.-Desv. (fig. 6) of West and Central Africa, the principal disseminator of *Trypanosoma gambiense* Dutton, causing sleeping sickness in man. These tsetse-flies exist only in shady places, and haunt the margins of lakes and water-courses where the banks are covered with vegetation. Specimens are shown of young and full-grown larvae (in the small glass vessel of alcohol), and of pupae, together with some of the soil in which they were found (in the glass-topped box). *Glossina palpalis*, like other tsetse-flies, but unlike the vast majority of flies in general, does not lay eggs; the female produces at intervals a single larva, or maggot, which is retained within the body of the mother until full

grown. The maggot of *G. palpalis* is dropped by the mother in a shady place near water, where the soil is loose or sandy, moderately dry, and often consisting of crumbling vegetation. On being deposited, the maggot buries itself in the loose earth; its skin then becomes dark in colour, contracts, and hardens into a barrel-shaped puparium or case, within which the change to the pupa or chrysalis takes place. A female fly of this species may produce from eight to ten larvae altogether, one at a time at intervals of nine or ten days.

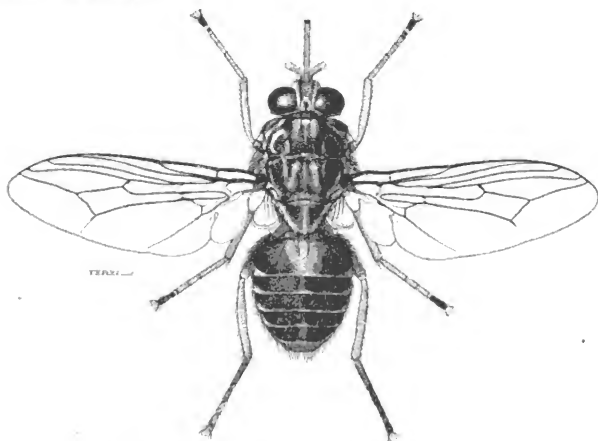


FIG. 6.—A TSETSE-FLY THAT SPREADS SLEEPING SICKNESS,
Glossina palpalis, female, $\times 5$.

Specimens of *Glossina palpalis* are shown in the attitude in which they rest. A resting tsetse-fly can be distinguished from any other blood-sucking fly with which it could possibly be confused by the fact that the wings, instead of diverging at the tips, lie closed flat over one another down the back like the blades of a pair of scissors, while the proboscis with which the bite is inflicted projects horizontally in front of the head.

Glossina morsitans Westw. is a widely distributed tsetse-fly (see map), spreading nagana among domestic animals, and in Nyasaland and Northern Rhodesia conveying to man the

form of sleeping sickness caused by *Trypanosoma rhodesiense* Stephens and Fantham. This species of tsetse-fly is usually confined to definite tracts of country, known as "fly-belts," often of very limited extent. Unlike *G. palpalis*, *G. morsitans* is not confined to the immediate vicinity of water. The female deposits its maggot or larva in hollows about the roots of trees, and not in the soil under bushes, where it might be found by the scratching of guinea-fowl and other birds in search of food. Some empty pupa-cases are shown.

In the larger of the two glass vessels are specimens of tsetse-flies (*Glossina palpalis*, *G. morsitans* and *G. tachinoides*) before and after a full meal, showing the extent to which the abdomen can be distended with blood. Tsetse-flies are dependent for their continued existence upon the blood of vertebrate animals, including man, wild and domesticated mammals, birds and reptiles. Contrary to what is the case in the majority of blood-sucking flies, such as mosquitoes and horse-flies, in which the females alone suck blood, in tsetse-flies the habit is common to both sexes. The amount of blood imbibed at one meal is relatively considerable, the fly's abdomen—originally empty and flat—becoming swollen out like a head in consequence.

The tsetse-flies on the second panel are examples of species which have not been proved to convey sleeping sickness to man, though many, if not all, are concerned in the dissemination of trypanosomiasis among domestic animals. The species exhibited are:—*Glossina caliginea* Austen, *G. pallicera* Bigot, *G. tachinoides* Westw., *G. pallidipes* Austen, *G. longipalpis* Wied., *G. austeni* Newst., *G. fusca* Walk., *G. nigrofusca* Newst., *G. brevipalpis* Newst., *G. medicorum* Austen, and *G. longipennis* Corti.

TABANID FLIES AND "CALABAR SWELLINGS."

The disease known as "Calabar swellings," a form of filariasis prevalent in West Africa, is caused by thin thread-worms of the species *Filaria (Loa) loa* Stiles, the larva of which undergoes its metamorphosis in the salivary glands of female tabanid flies of the genus *Chrysops*.

Tabanid flies are large flies, sometimes termed horse-flies or mangrove-flies, widely represented in tropical, subtropical and temperate parts of the world. Only the females suck blood. The larvae of the flies are carnivorous, and live in water, wet sand or mud, earth or decaying vegetable matter.

In the table-case that stands at the entrance to Bay I are shown examples of *Chrysops dimidiata* v. d. Wulp and *Chrysops silacea* Austen, both of which are known to be instrumental in the spread of the disease. Both species occur in West Africa, the former ranging from Portuguese West Africa to Ashanti, the latter through Southern and Northern Nigeria and the Belgian Congo.

For comparison with the two foregoing species are shown some tabanid flies that do not, or, at all events, are not definitely known to disseminate disease, although certain of them are suspected of spreading forms of trypanosomiasis among domestic animals. In many parts of tropical Africa tabanid flies are abundant at certain seasons, when owing to the bloodthirstiness and pertinacity of the females, the insects become an intolerable pest, both to man and to stock. The exhibited specimens belong mainly to the genera *Chrysops*, *Silvius*, *Pangonia*, *Tabanus*, *Haematopota* and *Hippocentrum*, and in each case the range of the species and any features of interest in their natural history are mentioned.

HOUSE-FLIES AND INTESTINAL DISEASES.

Many of the diseases broadly termed filth diseases are spread by house-flies; some of them are skin-diseases, others are diseases of the alimentary canal, such as enteric or typhoid fever, cholera, dysentery and infantile summer diarrhoea. House-flies are something more than disagreeable companions and pertinacious nuisances of the hot weather; they are dangerous by reason of their habit of settling upon food and contaminating it with such disease germs as they may happen to be carrying. In America the common house-fly has been termed the typhoid-fly, an unfortunate expression implying that typhoid fever is the principal, if not the only, disease that

is spread by the insect; in large towns, where the arrangements for the disposal of sewage are good, the greatest harm done by the house-fly is in the dissemination of infantile summer diarrhoea, with a large death rate. In camps and other places away from towns, where it is difficult to secure adequate disposal of human excreta, the danger of the spread of gastro-intestinal diseases by flies becomes very considerable. The organisms causing these diseases are mostly of a bacterial nature; enteric or typhoid fever is due to a motile bacillus (*Bacillus typhosus* Eberth-Gaffky), which in certain conditions exhibits from eight to twelve delicate threads or cilia projecting from the body (fig. 7).

In a table-case that stands on the East side of the Hall, between the statue of Sir Richard Owen and that of Prof. Huxley, are models of the common house-fly, *Musca domestica* Linn., adult female (fig. 8), and a group of eggs, a larva and a pupa, all

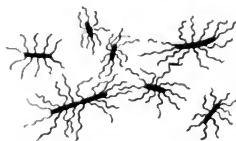


FIG. 7.—ORGANISMS OF TYPHOID FEVER,
Bacillus typhosus; $\times 1,500$.

enlarged 28 diameters. Actual specimens are also shown of the common house-fly and of three other species of house-fly, the most abundant of which in houses is the lesser house-fly, *Fannia canicularis* Linn.

The lesser house-fly is smaller than *Musca domestica*, and is often taken by the ignorant to be a common house-fly that has not yet grown up. As a matter of fact, a fly that has once emerged from its pupa-case does not increase in size. Occasionally small specimens of *Musca domestica* are met with, but these are undersized flies whose small dimensions are due to insufficiency or excessive dryness of food during the larval or maggot stage. The lesser house-fly differs in its habits from the common house-fly, and rarely associates with the latter. While the common house-fly is found largely in the kitchen and dining-room, and settles indiscriminately on the wall, the table, exposed food, and

one's hands and face, the lesser house-fly remains mostly on the wing, flying about with a curious darting movement beneath the gas-bracket or electrolier in the middle of the bedroom. The lesser house-fly appears earlier in the year than the common house-fly, and persists later, being still found in dwelling rooms as late as November. The lesser house-fly is closely related to the latrine-fly or privy-fly, *Fannia scalaris* Fabr., but the latter, although a dangerous disseminator of intestinal disease in villages and camps, is scarcely a house-fly; it rarely enters houses.

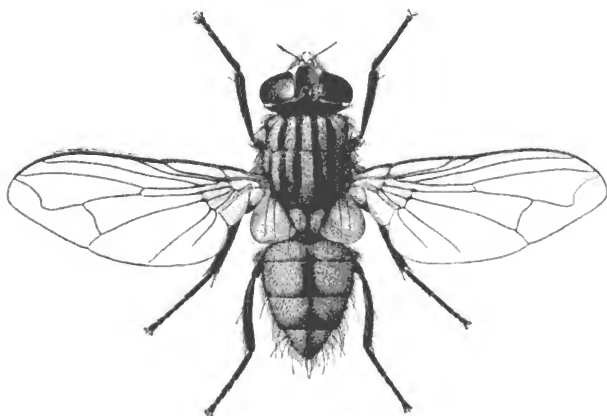


FIG. 8.—COMMON HOUSE-FLY,

Musca domestica, female, $\times 6$; largely responsible for the spread of typhoid fever and summer diarrhoea.

Shown in the same case are specimens of two other house-flies, *Muscina stabulans* Flin., a large fly, not frequent in its occurrence, and *Stomoxys calcitrans* Linn., commonly termed the stable-fly. This last is a biting, blood-sucking fly, common in the country and in suburbs, and met with sometimes in the middle of large towns. People who do not discriminate between the different kinds of house-fly imagine, when bitten by a *Stomoxys*, that it is an ordinary house-fly that has become particularly vicious. Critical examination

of the insect shows that it has a straight piercing proboscis projecting forwards from the head.

The common house-fly is incapable of biting; its proboscis is large and soft, and is situated on the under side of the head, and contains numerous minute tubes through which fluid nutriment is sucked. A fly cannot take in solid food; if the food is dry, as for instance a piece of sugar, the fly moistens it by ejecting salivary fluid or by regurgitating the fluid contents of its storage-stomach or crop. It is in this way, among others, that the fly infects food with disease organisms, for flies are indiscriminate in their habits, and the previous meal of the fly in question may have been made upon the excrement of a person suffering from typhoid, or of an infant ill with summer diarrhoea. The mere walking of a fly upon food may infect it with microbes, for the feet are hairy, and readily carry minute droplets of substance that the fly has recently been visiting.

At one end of the case is shown a representation of a tray of food such as might serve for a light lunch—a plate of ham, a roll, a few plums and a jug of milk—looking repellent by reason of the house-flies that swarm upon it. At the other end of the case is a representation of a heap of kitchen refuse which, by being allowed to accumulate for some time in the dustbin, forms a suitable breeding-ground for house-flies; for flies, although an indoor pest, do not breed indoors. In this exhibit are shown the four chief phases in the life-history—eggs, larvae or maggots, resting pupae in their brown coats, and adult flies. In the heap of rubbish can be recognised cinders, feathers, egg-shells, fish-bones, mouldy bread, vegetable refuse and tea leaves, the last two being particularly harmful because, by keeping the whole mass damp and in a state of fermentation, flies are attracted to lay their eggs in it, their instinct prompting them to deposit the eggs where the maggots, on hatching out, will find themselves in surroundings most suitable for their development. Flies breed also largely in heaps of stable manure, and any decaying and fermenting vegetable refuse in the fields.

Just as the mosquitoes that carry malaria and yellow fever can be kept in check by attacking their breeding haunts, by preventing accumulations of rain-water, by draining marshes and by spraying with paraffin oil tracts of stagnant water, so as to prevent the development of eggs and larvae that would grow into mosquitoes,

so in the case of house-flies, it is more practicable to attack the next generation than the present generation, that is to say, to prevent the development of the larvae rather than to attempt to destroy the winged flies, and this can be done by taking measures such that moist rubbish and stable manure are not allowed to accumulate and serve as breeding places for the flies.

A single female of the common house-fly lays from 120 to 150 eggs at a time, and may deposit five or six batches during its life; and since in very hot weather the entire life-cycle may be completed in about three weeks, it is easy to account for the enormous swarms of flies sometimes seen.

The attention of visitors is drawn to a pamphlet entitled "The House-Fly as a Danger to Health," which can be purchased in the Museum for a penny.

Blow-flies are not included in the series exhibited, for although they are flies that enter houses and settle on food, particularly cold meat and fish, they are not dangerous in the same sense as the common house-fly. They are not attracted to dung-heaps and other exposed faecal matter, and they breed in flesh, such as the carcase of a recently dead animal. Blow-flies are a nuisance principally from their habit of laying their eggs in any cold joint of meat to which they have access. The eggs soon develop into maggots or gentles, and owing to the power which these larvae have of liquifying the meat around them, the joint becomes putrid much more rapidly than if it had not become "fly-blown."

SHEEP BOT-FLY.

In one of the two sloping-faced table-cases in the middle of the floor of the Hall are shown a specimen of the bot-fly of the sheep, *Oestrus ovis* Linn., three larvae, and enlarged coloured drawings ($\times 6$) of the larva, pupa and adult female. The larvae or maggots of this fly live parasitically in the cavities in the front part of the head of the sheep, and when about to become pupae, escape from the nostrils and fall to the ground. After a time the winged flies escape, and lay their eggs in the nostrils of sheep.

In Algeria, especially in districts in which sheep are few and the human population fairly dense, the sheep bot-fly attacks the

Kabyl shepherds, laying its eggs, while flying, in the eyes, nostrils and lips; the larvae, when hatched, cause intense irritation of the conjunctiva, and of the cavities and sinuses of the nose and throat. The disease lasts about twelve days, and is known locally as thim'ni.

FLEAS AND PLAGUE.

Plague or bubonic pest is a disease of the rat, communicated from infected to healthy rats by fleas, of which *Xenopsylla cheopis* Rothsch. is the most important in tropical and subtropical countries. On the death of an infected rat the fleas leave the body, and if other rats are not available, will fasten upon man, and may communicate the disease. In man bubonic plague proves fatal in a large percentage of cases, and a marked feature of the disease is the enlargement of the superficial glands, such as those of the groin and armpit, into painful swellings or buboes.

Another type of plague, known as pneumonic plague, affects the lungs. The Manchurian epidemic of 1911 was of this type. The infection in this case appears to have originated from plague among the Mongolian marmots or tarbagans, *Marmota bobac* Pallas, that are trapped by the Manchurian hunters for the sake of their fur. The flea found upon the tarbagan is *Ceratophyllus silantiewi* Wagn.

In one of the table-cases in the middle of the floor of the Hall there are shown selected specimens and enlarged models of the tropical rat-flea, *Xenopsylla cheopis* Rothsch. (fig. 9), which, as stated above, is most responsible for the spread of plague in hot countries. The tropical rat-flea is found on several other mammals besides the rat; the hosts are mostly rodents, but include a few shrews. This species of flea has been spread by rats to such an extent that it is now found all over the world; it does not flourish, however, in cold climates.

The model on the pedestal is that of a male, enlarged 200 diameters. The names of the parts of the insect, so far as external features are concerned, are given in the coloured drawing below. At the ends of the case are shown enlarged models of the head and the hind end of a female tropical rat-flea ($\times 250$), so arranged

that they may be readily compared with the corresponding parts of the male.

Models are also shown of the egg and larva of the tropical rat-flea, enlarged 150 diameters. The eggs of fleas are ellipsoidal in shape, similar at the two ends, and of a translucent appearance, suggesting thin china. The eggs laid by the rat-flea fall out of the fur of the host, and remain on the ground, usually within the

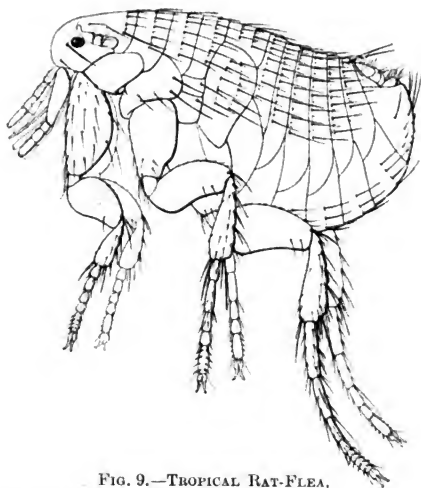


FIG. 9.—TROPICAL RAT-FLEA,

Xenopsylla cheopis, male, $\times 36$; largely responsible for the spread of plague.

nest, run or burrow of the rat, until in about a week they hatch out into active, maggot-like larvae.

The larvae of fleas are not parasitic; they live on the ground either in the nest or the run of the host, and feed on all kinds of refuse that may occur there, their mouth-parts being adapted for chewing, and unlike those of the adult. They have no eyes, and no legs, but move about by means of the hairs or bristles projecting from the body, and the pair of processes or "struts" at the hind end. After spinning cocoons and passing through a pupal or

D

resting phase, they become slowly transformed into fleas, which finally emerge from their cocoons, and invade the fur of new hosts.

On the small glass table in the case are shown transparent models of human red blood-corpuscles and plague bacilli, enlarged 6,000 diameters (fig. 10). Bubonic plague, the disease that is transmitted by the bite of various kinds of flea, of which *Xenopsylla cheopis* is the most important in tropical regions, so that it is sometimes termed the plague-flea, is due to the presence of minute bacterial organisms, known as *Bacillus pestis* Kit., occurring in the blood. These organisms were first discovered during the epidemic of plague in Hong Kong in 1894. The bacilli occur in the fluid part (plasma) of the blood, and not in the

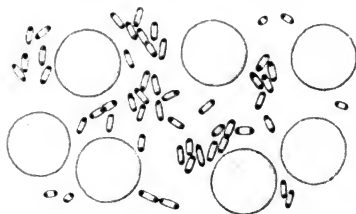


FIG. 10.—ORGANISMS OF PLAGUE,
Bacillus pestis, and red blood-corpuscles; $\times 1,500$.

corpuscles; they may have the form of small rods with rounded ends, and sometimes show a constriction across the middle. Occasionally they are found in chains or series set end to end; each bacillus repeatedly elongates and divides across, thus increasing the total number at a rapid rate.

On the floor of the case are shown actual specimens of the tropical rat-flea and its larva, mounted on slips of glass. The specimens are so small that no details can be seen; they are introduced into the series merely to give a correct impression of the real size.

Under the microscope that is set upon the table at the entrance to Bay X on the East side of the Hall, near the statue of Prof. Huxley, are shown specimens of the tropical rat-flea, *Xenopsylla cheopis*, in five stages of its life-history. Slide A shows

the eggs; the thinness of the translucent shell is seen in the two broken eggs. Slide B shows the larva, stained red with carmine solution; the head end is to the left. The body of the larva is seen to be sparsely covered with stiff hairs or bristles, and there are no eyes nor legs. Slide C shows an early pupa, shrinking in length while still within the hairy larval skin. The first traces of the legs can be seen. Slide D shows a later pupa, very transparent and delicate in texture, owing to a reconstruction of all the internal parts of the body which takes place at this period of development. The legs are of considerable length, and the body is assuming the size and shape of the flea. Slide E shows an adult male; the body is now yellow, with an external hard casing of chitin, produced into numerous hairs and spines.

Returning to the middle of the Hall, the visitor will see in one of the two sloping-faced table-cases an enlarged, coloured drawing ($\times 40$) of a female specimen of the human flea, *Pulex irritans* Linn. The flea of man is larger and darker in colour than the tropical rat-flea (*Xenopsylla cheopis*), and has larger stigmata or breathing pores, larger claws on the feet, and much larger eyes; the piercing mouth-parts, also, are stronger and broader. The long bristle which in the rat-flea passes backwards across or near the eye is much lower down in the flea of man; and in the latter there is no internal bar extending from the mid-coxa into the thorax—this last feature can only be seen in specimens that have been made transparent so as to render the internal structures visible. Other differences between the species occur in the sexual organs.

Under the microscope placed on the West side of the Hall near the entrance to Bay I. are shown twelve slides, of which nine are preparations of adult fleas of general interest.

A is a male tropical rat-flea, *Xenopsylla cheopis* Rothsch. (fig. 9). As already explained, this flea is common on rats (and other rodents) in warm countries, having become almost cosmopolitan in distribution. It is known to transmit the bacillus of bubonic plague from infected rats to man, and is frequently termed the plague-flea.

B is a male flea of the species *Ctenophthalmus agyrtes* Heller. This species of flea is common on rats, and also on field-mice, stoats and weasels, in Europe. It is not known to transmit any disease. It is distinguished from "A" by having no eyes, and by

having three spines on the lower edge (gena) of the head. There is also a comb of spines projecting back from the pronotum or first division of the thorax.

C is a male *Leptopsylla musculi* Duges, the common flea of the mouse, but also found on the rat. Though primarily European, it is now almost cosmopolitan. It has a comb of spines on the pronotum, but no eyes, and is distinguishable from "B" by having four genal spines instead of three.

D is a male *Ceratophyllus fasciatus* Bosc., a common rat-flea, almost cosmopolitan in distribution. It has eyes, and a comb of spines on the pronotum, but no genal spines.

E is a male *Ceratophyllus silantiewi* Wagn., the flea found on the Mongolian marmot, *Marmota bobac* Pallas, and responsible for the spread of pneumonic plague. It is with difficulty distinguishable from the common rat-flea (D).

F is a female cat-flea, *Ctenocephalus felis* Bouché, found not only on cats, but also on wild species of felidae, and on dogs. It is widely distributed, and is distinguished by having eyes, a comb of spines on the pronotum, and a row of eight spines (genal spines) at the lower edge of the head.

G is a female dog-flea, *Ctenocephalus canis* Curtis, found on cats as well as dogs. The flea resembles *Ctenocephalus felis*, but has the head more rounded.

H is a male human flea, *Pulex irritans* Linn. This flea is short and thick-set, with eyes, but no comb of spines on the pronotum. It is almost cosmopolitan in distribution.

J is a young female jigger flea, *Dermatophilus penetrans* Linn. The female jigger flea burrows into the human skin, and its abdomen becomes so enormously distended with eggs as to attain the size of a small pea. The part of the skin affected may become ulcerated and infected with various pathogenic bacteria, and so lead to serious consequences. Although a native of Mexico, Brazil and Argentina, the jigger flea is now spread also over most parts of tropical Africa, and has even reached India. It attacks other mammals besides man.

The slides K, L and M are preparations of a louse and two bugs, and will be referred to under their respective headings.

BED-BUGS AND DISEASE.

In one of the two sloping-faced table-cases in the middle of the floor of the Hall is a specimen and an enlarged, coloured drawing ($\times 20$) of a female bed-bug, *Cimex* or *Clinocoris lectularius* Linn.; and under the microscope at the entrance to Bay I are shown specimens (slides L and M) of this species and the bed-bug of tropical Africa and the Oriental Region, *Clinocoris rotundatus* Sign.

Clinocoris lectularius (fig. 11), although commonly termed the European bed-bug, is a parasite which by the facilities for travel

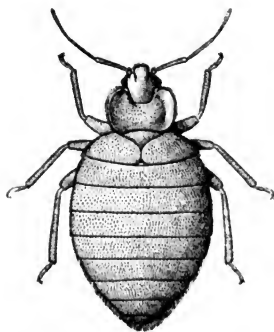


FIG. 11.—COMMON BED-BUG,
Clinocoris lectularius, male, $\times 10$.

now possible has been spread all over the temperate and tropical parts of the world. It differs from *C. rotundatus* by its relatively broader abdomen; the prothorax also is broader, and the lateral lobes project more forward, and almost reach the eyes. The form of the mouth-parts of a bed-bug are seen in slide L. The labium has the form of a segmented proboscis; the four bristles seen projecting from the front of the head are the two maxillae and two mandibles, which in the living insect lie within a groove in the labium.

The common bed-bug has been suspected of carrying the virus of various diseases, such as leprosy, typhus and relapsing fever,

from infected to healthy persons, and *Clinocoris rotundatus* is known to be the carrier of a piroplasma parasite, *Leishmania donovani* Laveran and Mesnil, the cause of the tropical disease kala-azar, common in India.

LICE AND DISEASE.

Apart from the irritation which they cause, in some cases so great as to lead to loss of sleep and nervous prostration, lice are noxious insects because of their capacity for spreading typhus fever and some forms of relapsing fever (those of Europe and North Africa); lice have also been suspected as the infective agent in certain cases of leprosy, tuberculosis and plague. The organism of typhus fever has so far not been identified. That the causal organism undergoes some part of its development in the louse is evident from the fact that lice are especially infective from the fifth to the seventh day after feeding upon a person suffering from typhus fever. The organisms of the relapsing fevers are spirochaetes, blood parasites of spirally twisted, thread-like form.

Lice feed entirely upon blood, which they suck through punctures made in the skin; they soon die when removed from the body, and differ in this respect from fleas and bugs. Three species of louse occur on man—the clothes-louse or body-louse, *Pediculus humanus* Linn. (fig. 12), the head-louse, *Pediculus capitis* de Geer, and the crab-louse, *Phthirus pubis* Linn. These are also found occasionally upon cats, dogs and monkeys living in association with man. Various kinds of mammals, from elephants to shrew-mice, have their own particular species of lice.

In one of the two sloping-faced cases in the middle of the Hall are shown some specimens and enlarged coloured drawings ($\times 50$) of the clothes-louse and head-louse. In the same case a series of five lenses is arranged over mounted specimens of a head-louse, some pieces of human hair with nits or eggs of the louse, a clothes-louse, a crab-louse, and a louse (*Pediculus schäffi* Fahr.) from a chimpanzee. Under the microscope near the bust of Sir William Flower, on the West side of the Hall, is shown a mounted specimen (slide K) of the clothes-louse.

The clothes-louse is larger than the head-louse, and the sides of the abdomen are less deeply cleft between the segments. The antennae are slightly thinner in the clothes-louse than in the head-louse, and the front border of the thorax is less rounded. Other differences occur in the female sexual organs. In the crab-louse the body is shorter than in the two former species, and the thorax is broader than the abdomen; along each side of the abdomen are projections which at their tips carry pencils of

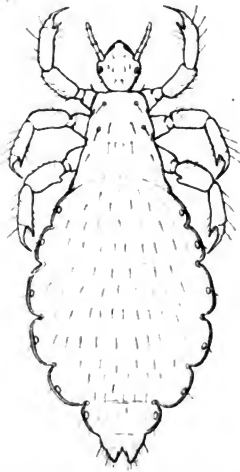


FIG. 12.—CLOTHES-LOUSE OR BODY-LOUSE,

Pediculus humanus, female, $\times 18$; largely responsible for the spread of typhus fever.

hairs. In the louse of the chimpanzee the lateral margins of the abdomen are straight in front, but behind they present the appearance of a saw.

A female louse lays four or five eggs a day for about a month, and then dies. There is no caterpillar or maggot stage; the young, on hatching out, differ from the adults only in their smaller size and in certain trifling differences of structure. As they grow they moult the skin three times before arriving at the adult

condition, which is reached in about twelve days from the time of the hatching of the egg.

Lice are commonest in the poorer districts of a town, and spread rapidly among the children in a school. In times of war lice are apt to become particularly troublesome owing to their rapid increase in numbers, and the ease with which they can spread in the crowded life of a camp; the men have usually but few opportunities for effecting a complete change of garments and otherwise cleansing themselves, and so the conditions are favourable for a continuance of the infestation.

The attention of visitors is directed to a pamphlet entitled "The Louse and its Relation to Disease," which can be purchased in the Museum for a penny.

TICKS AND DISEASE.

The transmission of several diseases caused by blood-parasites, known as spirochaetes, may be traced to the bite of ticks, *e.g.*, human tick-fever or relapsing fever of tropical Africa, due to *Spirochaeta duttoni* Novy and Knapp (fig. 13), conveyed from one person to another by the tick *Ornithodoros moubata* Murray (fig. 14); and spirochaetosis in fowls and cattle, the fowl-tick being *Argas persicus* Oken. A typhus-like disease in man, known as Rocky Mountain spotted fever, is spread by the tick *Dermacentor venustus* Banks, and a recently observed obscure affection known as tick-paralysis in man, sheep and dogs, has also been shown to be due to the effects of tick-bites. Concerning the blood-parasite of heartwater of sheep, etc., conveyed by the bont tick, *Amblyomma hebraeum* Koch, in South and Central Africa, but little is known. A somewhat similar disease, the East Coast fever of cattle, is due to *Theileria*, a blood-parasite which occurs within the red blood-corpuscles of the host, like the forms of *Piroplasma* (*Babesia* and *Nuttallia*), which cause redwater or Texas fever of cattle in many of the warmer parts of the world, malignant jaundice of dogs in India and South Africa, biliary fever of horses in Africa and India, and carriage of sheep in Southern Europe, all transmitted by ticks of the genera *Rhipicephalus*, *Margaropus*, and their allies.

In one of the two sloping-faced cases in the middle of the Hall,

between the main staircase and the statue of Sir Richard Owen, there is shown, on the North side, a series of ticks arranged in three groups. The first group consists of ticks that convey disease to human beings, and includes *Ornithodoros moubata* Murray, *Ornithodoros savignyi* Aud. and *Dermacentor venustus* Banks.

Ornithodoros moubata (fig. 14) is very widely distributed in Africa, and the regions where it is known to occur are marked in red in the map that is placed by the side of the specimens. This tick, which sometimes attacks domestic animals as well as human beings, transmits the blood-parasite *Spirochaeta duttoni* Novy and Knapp, the cause of the human relapsing fever of tropical Africa.

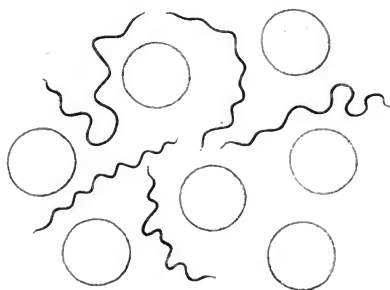


FIG. 13.—ORGANISMS OF AFRICAN RELAPSING FEVER,
Spirochaeta duttoni, and red blood-corpuscles; $\times 1,500$.

The larval stage of the tick is not well developed in this species, and is inert, the tick emerging from the eggshell as a nymph. After freeing itself from the larval skin, the nymph is ready to feed. It casts its skin several times before becoming adult, a moult taking place after each meal of blood. The female tick does not lay eggs until it has fed on blood. The spirochaetes are taken up by the tick whilst sucking blood from an infected person. They make their way into the ovaries of the tick, penetrating into the undeveloped eggs and multiplying within them. The first nymphal stage that develops from these eggs is capable of conveying the disease. The spirochaetes can be transmitted to the third generation of ticks, even if the second generation was fed on blood free from spirochaetes.

Ornithodoros savignyi is very widely distributed in Africa, from Egypt to Cape Colony, and is also recorded from Southern India. It occurs on both man and domestic animals, and experiments have shown that the species is capable of transmitting the human relapsing fever of tropical Africa.

Dermacentor venustus is a North American form, ranging from British Columbia southwards to Northern New Mexico, and from the foothills of the Rocky Mountains in Colorado to the base of the Cascade Range, in Oregon and California (see map). Almost all the small mammals found in the localities in which this tick occurs serve as hosts for the larvae and nymphs. The adult tick is

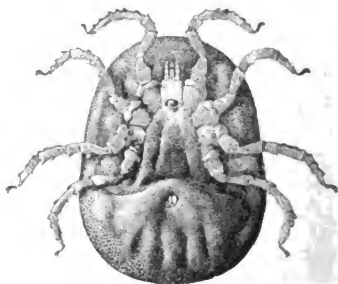


FIG. 14.—AN AFRICAN TICK,

Ornithodoros moulata, female, under surface, $\times 4$; largely responsible for the spread of the relapsing fever of Africa.

nearly always met with on the larger domestic animals, especially on horses and oxen. The species also attacks man, and transmits the spotted fever of the Rocky Mountains, a disease with a high rate of mortality. According to some authorities, more than one species has been included under the name *D. venustus*, and the species conveying Rocky Mountain fever should be called *D. andersoni* Stiles.

The second group exhibited comprises examples of ticks that convey disease to domestic animals, but not to human beings; it includes the following species:—

Rhipicephalus evertsi Nn. is a tick found in most parts of Africa (see map), and transmits East Coast fever of cattle and the

South African biliary fever of horses. It is known to attack oxen, sheep, horses and dogs, and has also been met with upon antelopes, giraffes and elephants.

Ixodes ricinus Linn. is apparently the chief carrier of redwater fever, a form of piroplasmosis, in cattle in Northern Europe. It ranges through Europe, North Africa, Transcaucasia, Arabia, China, Japan and North America. It is met with upon sheep, cattle, goats, horses, dogs, deer, hedgehogs, and many other mammals, also lizards, and occasionally on man.

Amblyomma hebraeum Koch is known as the bont tick; it is a common species in South Africa, and is distributed as far as Central Africa. Owing to the fact that it transmits heartwater in sheep, goats, and sometimes in cattle, this tick is of considerable importance to agriculturists. Further remarks upon the bont tick are given below.

The third group includes examples of ticks that are not known to convey disease to man or other vertebrates; three species are shown, as follows:—

Amblyomma cohaerens Dönitz is found in Uganda upon buffaloes.

Dermacentor rhinocerotis de Geer ranges from South Africa to Uganda and British East Africa, and is found usually upon the rhinoceros, but sometimes on antelopes.

Dermacentor circumguttatus Nn. is met with upon elephants in Uganda and West Africa.

In one of the table-cases in the middle of the floor of the Hall is a series of specimens and enlarged models of the bont tick, *Amblyomma hebraeum* Koch, an African tick parasitic upon sheep, goats and oxen. The exhibited series includes a drawing of a small group of eggs, a model of a larva enlarged to the same size as the models of the adult, namely 20 diameters, and another model of the same larva still further enlarged ($\times 120$) to show the details of structure. Models are shown of an adult male and female ($\times 20$), and actual specimens are mounted on the tablet between them. The great model in the middle of the case represents the female when fully gorged and distended with blood and eggs, magnified to the same extent ($\times 20$). Two actual specimens of gorged females, of the size of cherries, are shown in the small glass vessel of alcohol.

The bont tick is capable of transmitting to sheep, goats and

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(The Guide-books can be obtained at the Museum. Postage extra.)

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 Guide to the Races of Mankind (Anthropology), 8vo. 4d.
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History of the Collections:—

- Vol. I. Libraries; Botany; Geology; Minerals. 1904, 8vo. 15s.
 Vol. II. Zoology. 1906, 8vo. £1 10s.
 Vol. II. Appendix. By Dr. A. Günther, F.R.S. 1912, 8vo. 5s.
 Catalogue of the Library of the British Museum (Natural History).
 Vols. I.-V. 1903-15, 4to. £1 each.
 Report on the Zoological Collections made . . . during the Voyage of H.M.S. 'Alert,' 1881-82. 54 Plates. 1884, 8vo. £1 10s.
 Report on the Collections of Natural History made in the Antarctic Regions during the Voyage of the 'Southern Cross.' 53 Plates. 1902, roy. 8vo. £2.
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